POWER

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Know Your Power Costs

AS WE have pointed out repeatedly, one of the most vital necessities in power plant operation is knowing what the costs are from month to month and year to year. Every engineer in charge of a plant, no matter how small it may be, should have cost data at his finger tips, for his own satisfaction, if not for his actual salvation. It is important to know just where the money goes and for what.

We actually have heard of men—calling themselves engineers—who reasoned something like this: "Why should I bother my head about coal bills and operation costs? I don't pay the bills. I order only as much coal as I need; I don't throw any away. What more can I do? What difference would it make if I did keep track of what I burn?"

Other men argue along this line: "I know it is a good thing to keep track of the costs, but how can I do it when the boss will not put in automatic scales, recording water meters, steam-flow meters, recording and integrating wattmeters, etc.?"

If such men do not want to get into a rut and stay there, probably even if they merely hope to retain their present positions, they must change their attitude and *get busy*. The first requisite is to know what you are doing; the next, to try to discover some way to improve the operation. And having made the improvement, you want the figures in black and white to *prove* that you have been "up and doing."

The man who does not try simply because he thinks he can't accomplish anything unless he has an elaborate assortment of scales, meters, etc., is probably sincere enough in his intentions but a little shy of initiative. While he may not be able to get a complete or accurate analysis of the operating costs without a suitable equipment of testing and metering apparatus, he can get a good and fairly complete set of cost data by exercising a little thought and ingenuity.

In any event, he can get *some* information if he will but *try*.

We earnestly invite the attention of all operating engineers to the article on "Power Costs in a Manufacturing Plant" on page 814 of this issue. It is one of the best articles of its type we have received in a long time. Thoroughly practical, it gives an idea of what can be done by any resourceful man, no matter how scant his testing equipment may be.

True, the costs per kilowatt-hour and per thousand feet of air probably are not very exact, yet no one can maintain that the figures do not answer every need under the existing circumstances. They show the total yearly expense, the approximate unit costs for the purposes of comparing one year's operation with that of another, and, above all, they show convincingly that it was cheaper to maintain a private plant than to purchase current from an outside source at the prevailing contract rates.

What one man has done others can do also!

Power Costs in a Manufacturing Plant

By H. J. Mistele

How the economy of a new plant was increased by cleaning and improving the circulating-water system, stopping a careless waste of engine oil and by purchasing the coal which would evaporate the most water for the least money under the existing conditions.

Description of the system of records employed. Four years operating costs and a comparison of them with the cost of purchased current.

The present power plant of the Falk Co., of Milwaukee, Wis., steel founders and machinists, was completed early in the spring of 1907. It is brick and concrete, 100 ft. square and 50 ft. high. A dividing wall separates the engine room from the boiler room. As may be seen in Fig. 1, the engine-room floor is 10 ft. above the ground and boiler-room floor level, making a light and airy basement for the auxiliary machinery. The chimney, of reinforced concrete, is 180 ft. high and 8 ft. in inside diameter. The coal bunker, also of reinforced concrete, faces the boilers and the bottom inclines toward them so that the coal falls by gravity on the firing floor, as shown in Fig. 2. Hopper-bottom coal cars are hauled up an inclined track onto the trestle over the bunker with an electric hoist and the coal is emptied directly into the bunker.

In the boiler room are five 300-hp. Wickes vertical water-tube boilers which originally were hand fired but now have Swift stokers. Steam is generated at 150 lb. gage pressure. The boiler room also contains two Burnham duplex outside-packed plunger feed pumps 14x8x16 in. in size; one 6x4x6-in. Prescott duplex pump for operating the turbine cleaner, and one Crawley open feed-water heater

FIG. 1. POWER PLANT OF THE FALK CO., MILWAUKEE, WIS.

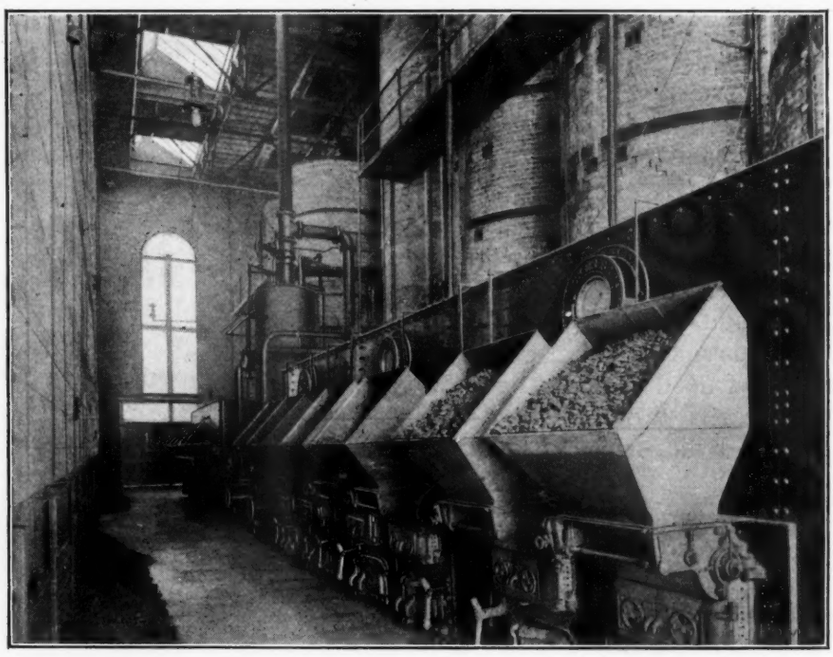

FIG. 2. PART OF THE BOILER ROOM

of 1000 hp. rated capacity. The four Tomlinson barometric condensers which serve the main units are also in the boiler room.

ENGINE-ROOM EQUIPMENT

Fig. 3 is a view in the engine room which contains two electric-generating and two air-compressing sets. The main generator, of 550 kw. capacity, is driven by a 20 and 42 by 42-in. Allis-Chalmers horizontal cross-compound Corliss engine, running at 100 r.p.m. For noon-hour service and at other times when the load is light, a 125-kw. auxiliary generator, driven by an 18x24-in. Allis-Chalmers vertical Corliss engine running at 125 r.p.m., is used. Direct current is generated at 250 volts.

The main air compressor is a horizontal two-stage cross-compound unit with 18- and 30-in. air cylinders, 18- and 36-in. steam cylinders and a stroke of 42 in., with a rated capacity of 2500 cu.ft. of air per minute when running at 75 r.p.m. The auxiliary compressor is a single-stage unit with 22-in. cylinders and a 36-in. stroke, rated at 1400 cu.ft. per minute at 90 r.p.m. The air is compressed to 80 lb. gage. Both units were built by the Allis-Chalmers Co.

In the basement, as shown in Fig. 4, are two 10-in. horizontal double-suction centrifugal pumps of 10,000-gal.-per-min. rated capacity, driven by a 6x6-in. American Blower Co. vertical engine running at 250 r.p.m., used for supplying river water to the condensers. The mean static head from the suction well to the pumps is 13 ft. and from the pumps to the condensers, 35 ft. Another pump of the same type, but 6 in. in size, is used for pumping sludge from the well. An 18x10x12-in. Prescott duplex underwriters' fire pump and a 10x7x12-in. Prescott duplex pump for general service are also in the basement.

CONDENSER TROUBLE

The writer took charge of the plant about three months after it was started. The first thing that attracted his attention was the fact that but 18 or 20 in. of vacuum was being carried. At the first opportunity the circulating-water pumps were taken down and examined. The parts were found choked with everything imaginable from fish to stones. The water is taken from a well that is supplied from a shallow river. After cleaning the pumps the 9-in. suction pipes were taken up and the strainers examined. The bottom of each pipe was fitted with a bell-shaped casting across the mouth of which a screen was fastened. This had become clogged and the effect of the vacuum had forced the screen part way up into the bell, admitting all the refuse to the pump. The bells were removed and sliding screens were substituted, which have eight times the area

of the former screens and which can be lifted and cleaned properly whenever they become choked. This settled the trouble with the condensing system and thereafter there was no trouble in maintaining 26 or 27 in. of vacuum.

Excessive Lubrication Cost

Unreasonably high lubricating bills were the occasion of the next investigation. All the bearings are lubricated by a gravity system and the consumption of engine oil ran as high as three barrels per month. The joints of the sheet-iron drip pans and crank housings were tightened and cemented with a plastic metal cement. The oil pumps, in the basement, are set in a pan and formerly a drain pipe led from this to the sump. It was found that the pump rods were leaking badly and the constant drip soon carried away a barrel of oil to the sump. The oil end of the pump tray was properly piped so that all the drip from the rods drained back into the return reservoir instead of to the sump. After the system had been put in order the oil consumption dropped from three barrels per month to four barrels per year.

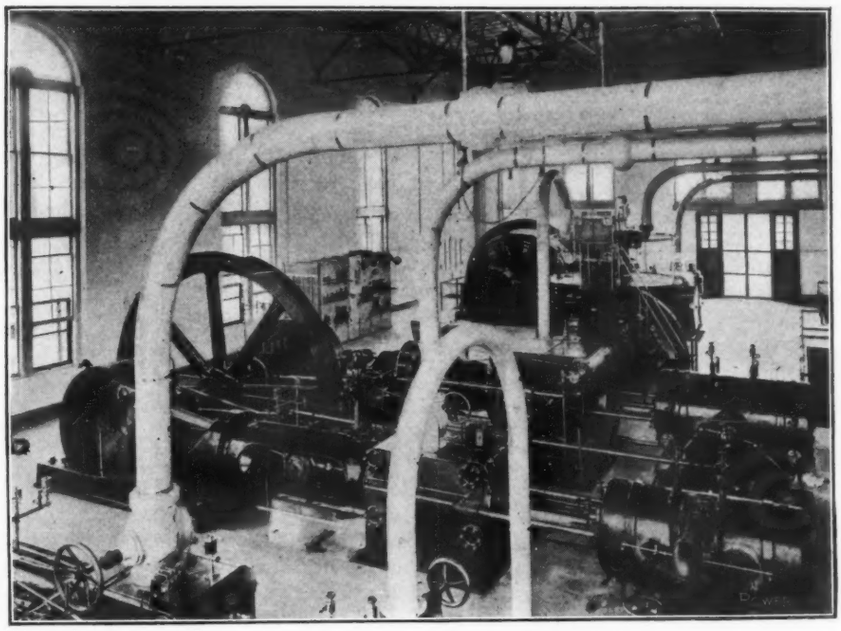

Fig. 3. A View in the Engine Room

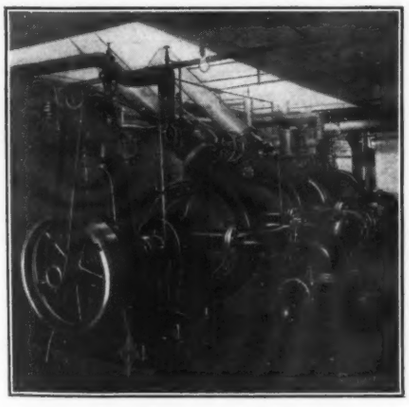

Fig. 4. The Circulating Water Pumps in the Basement

Studying the Fuel Problem

During the fall of 1907 the fuel question was taken up. It was attacked in the most practical way as the sole object was to ascertain what coal would evaporate 1000 lb. of water the cheapest under the conditions existing in the plant, regardless of the number of heat units it contained. One of the boilers was equipped with a hot-water meter and the usual appliances for making the necessary observations. The coal being used at the time was Pittsburgh mine-run, costing $3.20 per ton in the bunkers. Five tests were made with this coal. The results showed that the average cost of evaporating 1000 lb. of water from and at 212 deg. F. was 18.24c.

The next grade tested was Youghiogheny screenings costing $2.75 per ton. Six tests were conducted with this coal and the average cost of evaporating 1000 lb. of water from and at 212 deg. F. was found to be 16.84c., indicating a saving of 7.7 per cent. over the Pittsburgh mine-run coal. Consequently, Youghiogheny screenings were used during 1908, except a few carloads of other coals that were accepted for test but from which no better results were obtained.

Late in the fall of 1908, Hocking screenings at $2.35 per ton were tried. Three tests were conducted, which showed that the average cost of evaporating 1000 lb. of water from and at 212 deg. F. was 16.5c. This coal was used all during 1909 in the spring of which year a reduction of 25c. per ton was granted, making the cost $2.10 per ton. This price prevailed for one year. Five tests were made with the $2.10 coal and the average cost of evaporating 1000 lb. of water from and at 212 deg. was found to be 14.6c., showing a saving of 13.3 per cent. over Youghiogheny screenings and 20 per cent. over the Pittsburgh mine-run. In the spring of 1910 the cost per ton went back to $2.35 and has remained there ever since.

In the fall of 1911 the question came up as to whether the use of mechanical stokers would result in greater economy. One of the boilers was fitted with a Swift stoker and four tests were made, followed by two tests with hand firing. The results indicated an improvement in economy of 7.5 per cent. in favor of the stoker. As a result all of the boilers were equipped with stokers.

THE FALK COMPANY

POWER HOUSE DAILY REPORT.

For Twenty-four Hours commencing 6 P. M. the Day of 191

EQUIPMENT	Started	Stopped	Hours Run	Rev.	Watt Meters 7 A. M.	Watt Meters 6 P. M.	K. W. Generated Day	K. W. Generated Night	TOTAL	GENERAL REMARKS
Generator No. 1										Weather
Generator No. 2										
Generator No. 3										
COMPRESSORS					Counters 7 A. M.	Counters 6 P. M.	The Co. Pl. of Air Day	The Co. Pl. of Air Night	TOTAL	
Air Comp. No. 1										
Air Comp. No. 2										
CENTRIFUGAL PUMP										
Pump No. 1										
Pump No. 2										
Pump No. 3										
BOILER FEED PUMPS			Dup. run		Counters 7 A. M.	Counters 6 P. M.	Double Strokes Day	Double Strokes Night	TOTAL	
Pump No. 1										
Pump No. 2										
Fire Pump										
BOILERS	In	Out	Days Run	When Washed	Coal Received Car No.	Coal Received Contractor	Tonnage	Kind of Coal	Hours Unbanked	
Boiler No. 1										
Boiler No. 2										
Boiler No. 3										
Boiler No. 4										Engineer
Boiler No. 5										

Fig. 5. Daily Report Sheet (Actual Size 14x8½ in.)

All of the foregoing tests were conducted under everyday working conditions and when the boilers were operating considerably below rating. The results show what can be accomplished by

experimenting with different grades of coal. Several years ago the writer tested six different grades of coal in another plant and under different conditions and got just the opposite results. The highest priced coal yielded the most economical results.

System of Records

The power-plant records are kept on forms, shown in Figs. 5 and 6, which are filed in a loose-leaf book. The readings are taken at 7 a.m. and 6 p.m., 11 hr. constituting the day run and 13 hr. the night run. Records are kept of each night and day run together with the total for each 24 hr. The number of cubic feet of air delivered is estimated from the revolution counter readings. The daily reports are on yellow paper and the monthly on pink, facilitating their distinction in the loose-leaf file. All repairs or important occurrences are entered in the daily reports.

THE FALK COMPANY.
POWER HOUSE MONTHLY REPORT.

Month of 19

	GENERAL REMARKS
Total K. W. H. Generated	
Average per Day of 24 Hours (Days)	
Average per Day of 11 Hours	
Average per Night of 13 Hours	
Average Amperes per Day	
Average Amperes per Night	
Percentage above below last Month	
Total Cubic Feet of free Air delivered	
Average per Day of 24 Hours (Days)	
Average per Day of 11 Hours	
Average per Night of 13 Hours	
Total Revolutions	
Percentage above below last Month	
Coal in Bunker on first of Month Tons	
Coal Received during Month Tons	
Coal Consumed during Month	
Coal in Bunker at end of Month	

Engineer

FIG. 6. MONTHLY REPORT SHEET (ACTUAL SIZE 14x18½ IN.)

At the end of the year the monthly reports are totaled and averaged and the figures are arranged as shown in Table 1. In reducing the quantity of air compressed to its equivalent in kilowatt-hours it is estimated that 0.105 kw. is required to compress 1 cu.ft. of air per minute. This theoretical figure is only approximately correct, but answers for comparing one year's work with another.

Besides supplying current and compressed air, the power plant furnishes high-pressure steam for heating throughout the works, and for operating various steam hammers, sump pumps, oil pumps, etc. The use of live steam for heating was considered more economical than exhaust steam because foundries do not require heating except for short intervals during extremely cold weather and the greater economy secured with condensing engines more than offsets the relatively small loss in the present case due to the use of live steam.

Analysis of Yearly Costs

A large amount of coal is required for maintaining steam on the works for power purposes because of the great area covered and consequently the great loss due to condensation.

In Table 1, all of the coal consumed is charged against the power and air output, making the cost seem higher than it should. This is done because the plant is not arranged so that a close record can conveniently be kept of the steam distribution.

This power plant is the second the company has had to build within 10 years because of the increase in its business. When the present equipment was first put into operation the load was less than 50 per cent. of its rated capacity and the actual cost of current and compressed air was relatively high because of this inefficient loading. By 1910 the current and air output had greatly increased; hence the machines operated at or near rating for longer periods and the actual economy was much better. Then, too, as the heating load remained nearly the same, and as the quantity of steam required for power in the works increased but slightly, the outside steam charged against unit current and air output was much less, resulting in a better looking cost figure. The third factor in reducing the unit cost was the use of cheaper coal and the installation of mechanical stokers.

It will be noticed that the cost figures for 1911 show an increase of 10 per cent. in unit cost. Part of this increase is chargeable to the increase in the cost of coal per ton; another part is due to greater heating demands during January, February and March, and, finally, an extra pump used for a sand slusher was operated for the greater part of the year, for which the power plant has received no credit in the report.

When the last two boilers were installed in September, 1911, one was so arranged that it could be isolated and employed solely for supplying steam to the works. A seven-day test was then conducted to determine the amounts of steam required for this work. It was found that the average weight of coal consumed for this purpose was 8700 lb. per 24 hr. Deducting this from the weight of coal consumed for power and air, the approximate weight of coal consumed per kilowatt-hour under average conditions was estimated to be 4.35 lb. Table 2 is based on these figures.

The first column gives the estimated weight of coal consumed for various purposes. The second column gives the price of the coal based on the average cost per ton throughout the year, including switching charges. The fourth column gives the cost of labor. This item was estimated as follows:

The salaries of the three firemen and half that of the chief engineer were

TABLE 1. SUMMARY OF POWER COSTS

	1908	1909	1910	1911
Total current to swbd., kw.-hr.	836,400	1,057,600	2,082,000	1,950,300
Maximum	(Oct.) 86,200	(Dec.) 132,900	(Sept.) 206,800	(Oct.) 196,300
Minimum	(Feb.) 53,900	(May) 65,600	(Feb.) 134,000	(Feb.) 128,500
Average (12 months)	69,700	88,133	173,500	162,525
Increase over previous year, per cent		26	97	(Decrease) 6.33
Air delivered, cu.ft.	191,563,100	270,946,100	398,710,500	368,911,600
Maximum	(Aug.) 19,466,500	(Dec.) 28,498,000	(Aug.) 41,920,500	(Oct.) 36,467,800
Minimum	Jan.) 10,262,000	(Jan.) 15,684,100	(Dec.) 24,176,700	(Feb.) 24,400,000
Average (12 months)	15,963,600	22,578,840	32,225,875	30,742,600
Increase over previous year, per cent		42	47	(Decrease) 7.5
Air equivalent in kw.-hr.	333,450	471,626	694,022	642,150
Total output expressed in kw.-hr.	1,169,850	1,529,226	2,776,022	2,592,450
Increase over previous year, per cent		31	81	(Decrease) 6.6
Total coal consumption, tons	5,108	6,400	9,153	8,966
Cost of coal	$15,275	$14,193	$20,741	$21,494
Coal consumed per kw.-hr., lb.	8.7	8.37	6.59	6.92
Cost of coal per kw.-hr., ct.	1.3	0.928	0.747	0.829
Total cost of labor	$4,470	$4,590	$5,430	$5,625
Cost of labor per kw.-hr., ct.	0.38	0.3	0.195	0.217
Cost of oil and waste	$350	$340	$390	$375
Cost of oil and waste per kw.-hr., ct.	0.03	0.02	0.014	0.014
Total operating cost	$20,095	$19,123	$26,561	$27,495
Total cost per kw.-hr., ct.	1.71	1.25	0.956	1.06
Reduction over previous year, per cent		27	24	(Increase) 10

charged against the total coal consumption, and the labor cost for supplying steam to the works and for heating is based on this figure. The cost of labor charged against power and air combined equals the cost of labor per ton of coal fired times the number of tons used for power and air plus the salaries of the two assistant engineers plus half that of the chief engineer. From this the individual cost of labor for power and air is estimated from the ratio of coal used for each purpose to the total quantity used for both purposes. In the fifth column the cost of oil and waste is charged against power and air.

TABLE 2. DISTRIBUTION OF COSTS FOR 1911

	1 Coal Distribution tons	2 Cost of Coal at $2.397 per ton	3 Coal Distribution in per cent.	4 Labor Cost Distribution	5 Total Cost Distribution	6 Total Cost Distribution in per cent.
Power supplied to main works	2890.65	$6930	32.2	$2304	$9426	34.3
Power supplied to branch works	1351.25	3239	15.1	1078	4406	16.0
Air supplied to main works	1396.60	3348	15.6	1113	4555	16.6
Steam supplied to main works	1587.75	3806	17.7	540	4346	15.8
Steam for heating	1739.75	4171	19.4	590	4762	17.3
Totals	8966	$21,494	100	$5625	$27,495	100

Saving Effected

Table 3 compares the cost of manufacturing the current with the cost of purchasing it at prevailing contract rates. From this it will be seen that the average purchase cost per kilowatt-hour during 1911 would have been 1.636c., whereas the actual cost of production was but 1.06c., even when the cost of heating and supplying steam to the works was charged against the power item. The maximum demand charge of the public-service company is based on a 15-min. period whereas the peak given in Table 3 is for an entire day run of 11 hr. The peaks for short intervals often run fully 100 kw. higher than those given in the table and hence the monthly demand charges would probably be $200 or more higher than those given, or upward of $2400 more per year.

In estimating the total actual saving, the first, second and third items in column 5, Table 2, were added, giving a total of $18,387. This, subtracted from the total estimated cost of purchased current, gives $42,408 — $18,387 = $24,021 in favor of the power plant. The plant complete cost $160,000, it is 5 years old and practically as good as new. If 10 per cent. is allowed for depreciation, insurance, taxes and general upkeep, there would still be $24,021 — $16,000 = $8021 remaining, or 5 per cent. on the original investment. And this, after charging the power plant with everything except the cost of coal and labor for heating and supplying steam to the works.

During the first two years the showing was not quite so good for self-evident reasons but it will be conceded that it was sufficiently satisfactory when all factors are taken into consideration.

Details of Operation

Every car of coal is washed before being hauled over the bunkers. The bunkers are graduated and at the first of the month the coal is measured up and the amount recorded on the monthly report. It might be mentioned that generally there are between 30 and 60 days in the summer when it is necessary to use Youghiogheny screenings instead of Hocking, due to the fact that there is no Hocking in the market.

The 550-kw. generator operated 11 hr. per day until September, 1909, and the 125-kw. generator operated 13 hr. per night until that date. Since that time the 550-kw. has operated 24 hr. per day for 6 days a week and the 125-kw. has operated Sundays and Sunday nights. The compressor operates 7 nights and 6 days per week. During the lunch hours and between shifts and on Saturdays and Sundays, with practically no load, the operating conditions are very unfavorable from an economical standpoint.

Maintenance and Repairs

The question of maintenance and repairs has not been mentioned in the reports because they are so small that the costs would not have had any material effect on the yearly costs. There are 42 stuffing-boxes on the engines and during the five years' operation the packing on one valve stem has been renewed. One new set of trip steels has been put on, two new sets of brushes have been put on the generators, the small generator commutator has been turned off twice, one rocker-arm and a reach rod on the compressor have been renewed, two new shafts and sets of bushings have been obtained for the centrifugal pumps, three new tubes have been put in the boilers, the brick parts of the furnaces have been renewed once, the boiler-feed pump plungers have been trued up twice and the plungers have been packed once a year. This, with the ordinary valve-stem packing required throughout the house, covers all renewals and extra supplies.

TABLE 3. DISTRIBUTION OF LOAD FOR 1911

	Current Generated kw.-hr.	Max. Output in 11 hr. kw.-hr.	Air Output cu.ft.	Air Equivalent kw.-hr.	Max. Air Output in in 11 hr. cu.ft.	Electrical Peak Load kw.	Air Peak Load equivalent kw.	Total Peak Load kw.	Central Station Rates: Max. Demand Charge	Central Station Rates: Current Charge	Central Station Rates: Total
						for 11 hr.	for 11 hr.	for 11 hr.			
January	151,000	4900	25,650,000	44,646	1,040,000	466	172	638	$1,306	$2,057.46	$3,363.46
February	128,500	4100	24,400,000	42,471	957,700	390	155	545	1,140	1,810.71	2,950.71
March	155,000	4300	33,630,000	58,536	1,044,600	409	173	582	1,194	2,236.36	3,430.36
April	156,500	4700	30,002,900	52,223	1,027,000	447	170	617	1,264	2,188.23	3,452.23
May	150,500	4700	28,591,600	49,766	961,800	447	160	607	1,244	2,103.66	3,347.66
June	147,000	4300	30,403,700	52,921	1,037,300	390	172	562	1,154	2,100.21	3,254.21
July	152,500	4900	31,589,000	54,985	1,140,400	466	189	655	1,340	2,175.85	3,515.85
August	181,500	4600	35,044,500	60,998	1,116,300	438	185	623	1,276	2,525.98	3,801.98
September	186,500	4700	32,438,400	56,462	1,411,700	447	234	681	1,392	2,530.62	3,922.62
October	196,300	4800	36,467,800	63,476	1,129,100	457	187	644	1,318	2,698.76	4,016.76
November	179,000	4900	30,359,200	52,843	1,037,300	466	171	637	1,304	2,419.43	3,723.43
December	166,000	5000	30,334,500	52,800	1,078,500	476	179	655	1,340	2,289.00	3,629.00
Totals	1,950,300		368,911,600	642,127					$15,272	$27,136.27	$42,408.27

McEwen Flexible Steel Coupling

A new form of cast-steel flexible coupling is being introduced by the McEwen Bros., Wellsville, N. Y. This coupling has a small diameter and mass, and consequently small inertia.

Key pins extend through the shafts and are set at right angles. The coupling will connect two shafts that are considerably out of line and is free of noise or tendency toward serious wear. Very little clearance is required for removing any part.

The coupling is suitable for use under high speeds and severe conditions such as reversible motor drive for machine tools, blowers, rotary pumps, motors, generators, turbines and line-shaft connections, and on machinery of any speeds.

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

In which more pump rooms are visited and Hunter explains the construction and operation of the jet condenser.

After further discussion regarding the Goyne pump we went past the shaft to a second pump room, where the cat was awaiting us, the rat evidently having escaped. Here we found a 26, 45 and 14 by 48-in. duplex compound outside-packed pump working against a head and suction lift of 608 ft., with a capacity of 2600 gal. of mine water per minute.

This pump room was similar to the other. The floor was of concrete and the walls were of cement instead of half concrete and pipe, but the ceiling had I-beams across it supporting discarded pipe over which earth had been filled in. A view in the pump room showing the ceiling construction is given in Fig. 1.

In the cement side walls of the room, lockers had been built, with metal doors, an improvement over the other pump room, which was supplied with iron chests for keeping small supplies. These chests and lockers were to minimize fire risks and also to protect the supplies from dust and injury.

At another mine I later saw a storeroom which had been constructed handy to the pump room. It was made with concrete floor and walls, with ventilating windows in the end wall. The roof was of the natural slate formation. Spare pumps, parts, packing, etc., were kept for immediate use, and it was the pump runner's business to keep the supplies on hand, never allowing the stock to run out, for when a mine pump requires new valves, packing, etc., there is no time to send to distant cities for supplies. Fig. 2 gives an idea of the room.

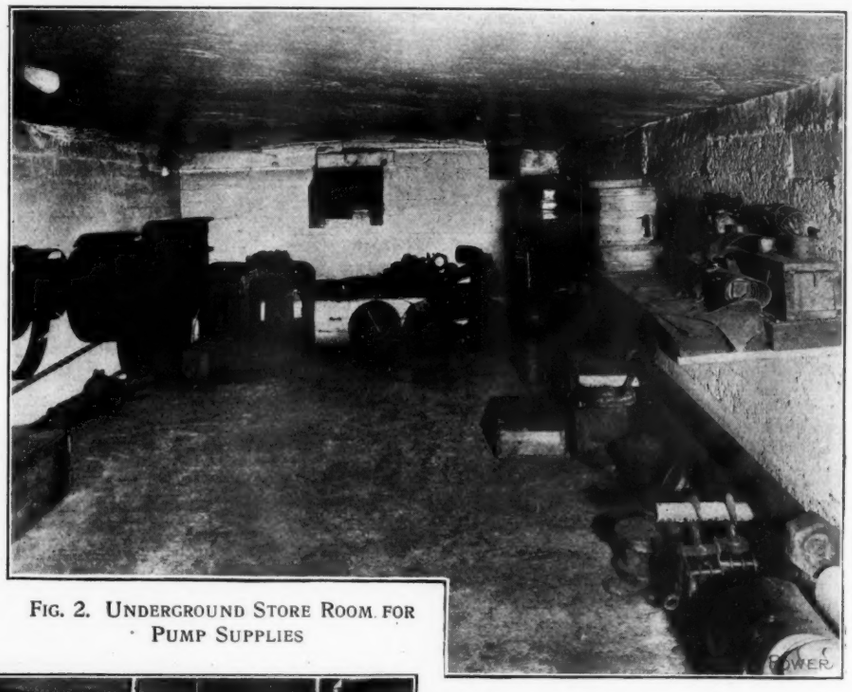

FIG. 2. UNDERGROUND STORE ROOM FOR PUMP SUPPLIES

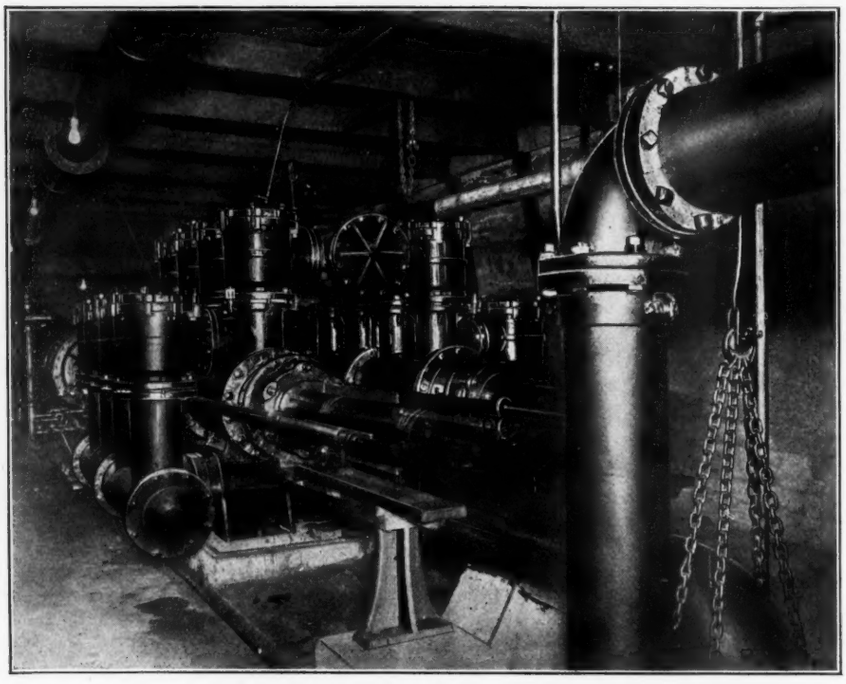

FIG. 1. A PUMP ROOM IN THE NO. 2 COLLIERY OF THE SUSQUEHANNA COAL CO.

All pump rooms are not so well laid out as those I had visited, and I later saw one, Fig. 3, that was dirty, hot and congested. The chief machinist was engaged at the time in installing a small pump, under extremely unfavorable conditions, as the room was restricted.

Reaching the rear end of the pump room we came to the 12 and 18 by 18-in. Jeanesville jet condenser, the gage of which registered 25 in. of vacuum.

"I thought you said the surface condenser was the most economical and we find jet condensers are used with all of the mine steam pumps we have seen. How do you account for that?" I asked. "Don't mine people go in for economy?"

Hunter grinned as if amused. "You think you have me there, don't you? Well, a surface condenser is more economical than a jet condenser where the water is reasonably clean and free from acid or alkali. It is adapted for mine work where it can be piped to the suction line to the pump, and the incoming water to the pump used for condensing purposes. This gives a large amount of cooling water that is rapidly moved by the pump and cuts out the necessity of a circulating pump."

"Are they difficult to operate?" I asked, watching the jerking motion of the air pump.

"No, they are simple in operation, and the vacuum pump uses a small quantity of steam as compared with the independent surface condenser. The trouble is that acid in the mine water attacks the metal and causes a heap of trouble. Sometimes I think the water gets worse each year.

If the water is dirty the tubes are pretty apt to become coated, which reduces the heat transference through them."

"Well, won't the acid water attack the jet condenser just as readily?"

"No, for the reason that the water cylinder is bushed with a heavy phosphor-bronze lining, where acid or alkali water is used for condensing. Furthermore, the jet condenser makes a simple and reliable machine for use in a mine where skilled men are not employed.

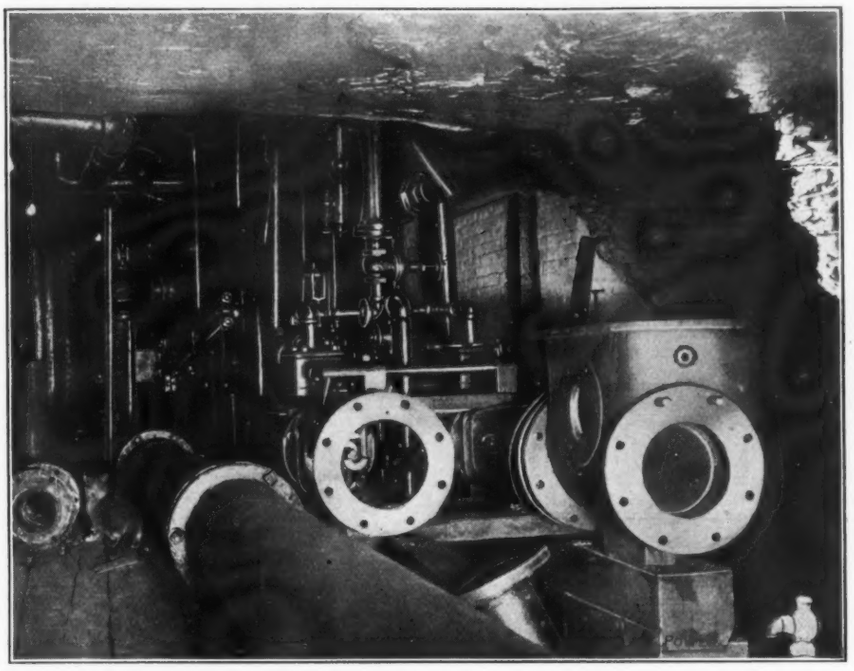

FIG. 3. INSTALLING A PUMP IN RESTRICTED SURROUNDINGS

All valves in the water end are generally made of rubber, and seat on phosphor-bronze seats under curved phosphor-bronze guards. This construction makes a good exhaust valve, and valve springs are eliminated. In fact, all important details about the condenser are made of phosphor-bronze.

"The steam end is fitted with the ordinary duplex valve motion with modifications which insure a full piston stroke." A sectional view of the condenser under discussion is shown in Fig. 4.

"Seems to be a mighty small machine to handle all of the exhaust from that large pump; how does it do it?"

"The principles involved and the method of operating jet condensers are the same in all makes. It consists of a steam-driven pump piston which removes the water in the chamber *A*." Hunter designated the position on the sketch shown in Fig. 4. "The steam and water valves act exactly as in an ordinary direct-acting steam pump and the only difference is that the jet condenser has a condensing chamber attached to it instead of an air chamber. The condensing chamber has an inlet for exhaust steam, and an outlet for the condensing water."

Referring to the sketch, Hunter pointed out how the exhaust steam is condensed. "To condense steam," said he, "it must be cooled and the best available agent is the water from the mine sump. The condensing chamber has a cone valve *B*, and the outlet of the elbow is piped to the sump. The exhaust steam from the steam end of the condenser is piped to the condenser chamber, and the discharge of the condensing water and condensed steam is out through the outlet *C*."

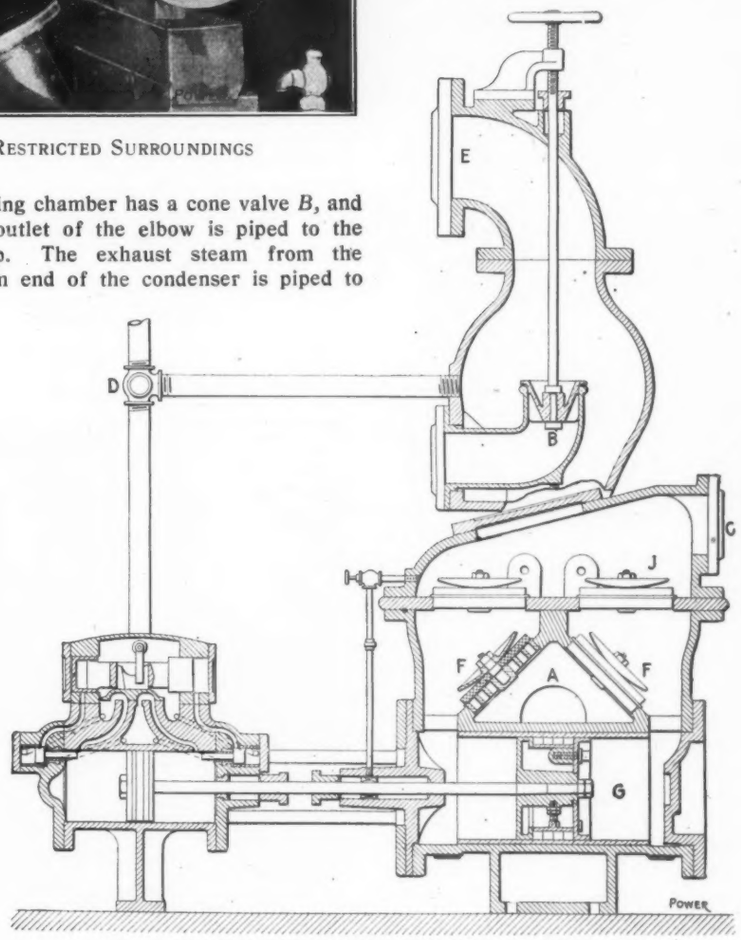

FIG. 4. SECTION OF JEANESVILLE JET CONDENSER

"I should think the pump would get flooded with the combined steam and condensing water, for the volume of steam from the mine pump must be enormous as compared with the size of the condensing chamber."

"One would assume such to be the case, but you see 1 cu.ft. of water evaporated into steam will have a volume of approximately 1600 cu.ft. Reversing conditions and each 1600 cu.ft. of steam when condensed will occupy but 1 cu.ft. and weighs 62.4 lb., or an equivalent of 7½ gal. Between 20 and 30 times the weight of steam is usually allowed for condensing water, so for each cubic foot of steam condensed the air pump would have to handle 225 gal. of cooling water.

"This condenser is capable of handling 700 gal. of injection water at 70 deg. temperature and will condense 14,000 lb. of steam per hour. If the water is above 70 deg. temperature more will be required to do the work. Do you get me?"

"Sure, and now that you have told me about everything except what I wanted to know, tell me how the thing works."

"All right," replied Hunter with a laugh, "but if I had not told you how the condenser was made you would have asked, so I would have had to cover the ground anyway.

"Before starting a jet condenser, the

drain cocks on the steam cylinder are opened and the three-way cock *D* in the exhaust pipe is turned to exhaust to the atmosphere. Then steam is turned on, the condenser is started slowly and the drip cocks are closed after the steam cylinder has been cleared of water.

"As soon as the condenser has taken water in through the cone valve, which is open, the steam from the pump exhaust is turned into the condensing chamber. The condenser is always started before the main mine pump, and after the latter is running smoothly the cone valve *B* is throttled down to give just enough water to maintain a vacuum of 25 or 26 in. The stroke of the piston is adjusted by opening or closing the cushion valve in the steam cylinder."

"Then how do you know when the condenser is running right?"

"The condenser water piston should run away from the water, about 1½ in. at the beginning of the stroke, which will be indicated by the jumping forward motion of the piston during the stroke. This will give the best vacuum and prevent backing the water into the low-pressure cylinder of the mine pump. The hot well discharge should be at a temperature of between 100 and 110 deg. F."

"Now, with the pump and condenser in operation, what happens? The steam from the mine pump enters the condenser chamber at *E*, and a spray of cold water is passing up through the cone valve *B*. The hot steam striking the cold water is condensed and passed through an outside connection to the chamber *A* and out through the valves *F* to the water cylinder, as the piston is moved from one to the other. If the water piston were moving toward the end *G* of the cylinder the water would be forced out through the valve *J* and discharge *C*. Water would, at the same time, pass from the chamber *A* to the opposite end of the cylinder. On the return stroke the water passes up through the other discharge valve. That is all there is to it."

"Well, as most pump pistons leak, why don't air leak into the water cylinder?"

"For the reason the stuffing-box is water-sealed by water from the discharge chamber. If the piston packing does get to leaking the water will be drawn into the cylinder instead of air."

After Hunter made these last explanations we left the pump room and ascended to the surface, to find that night had settled down and the yard, except for a light here and there, was as black as the depths of the mine below.

Cooling Ponds for Condensing Water*

The tests described were made to determine how large a reservoir is necessary to allow water from a condenser to cool sufficiently for reuse. The author's conclusion is that with engines having a water rate of 15 lb. and a vacuum of 26 in. a reservoir having a surface of 120 sq. ft. per hp. would be ample in the northern part of the United States.

*Paper presented at the Cleveland meeting of the American Society of Mechanical Engineers.

The tests described in this paper were made with the idea of determining if possible, a fairly reliable factor by the use of which the necessary size of a cooling reservoir for condenser water could be predetermined for any assumed power and weather conditions.

In 1908, while designing the mill for the Crescent Portland Cement Co. at Wampum, Penn., it was found necessary to install a cooling device for the condensing water from the engines. The mill stands on a level plateau about 110 ft. above the Beaver River and to pump water from the river for condensers meant a considerable expense for power. On the side of the plateau farthest from the river was a natural depression alongside the Erie division of the Pennsylvania R.R. which offered a desirable location for a reservoir (Fig. 1). After a diligent search, no data were found as to how large a reservoir had to be to give the necessary cooling effect to the water, so that it might be used continuously. A dam, however, was built 275 ft. long and 18 ft. high, of skeleton reinforced concrete construction which would impound about 6½ acres of water (Fig. 2).

Three tests were made during the year 1911, each of one week's duration, to determine the heat radiation from the surface of the reservoir. These tests were made in May when the temperature was moderate, in July when the temperature was high and in November when the temperature was low. Readings were taken of the temperature of the river water, the intake water to the power house, the tail water from the condenser and of the air. The vacuum, the power, the amount of water pumped from the river to the reservoir, and the rainfall were also recorded. These data were taken by James Toler, chief engineer of the Crescent plant, and by the writer's assistant, John E. Mason. Unfortunately, the temperature of the rain was not taken, but it has been assumed the same as the temperature of the air, so that the figures for that are only approximate, but a difference of 10 deg. in the temperature of the rain would not alter the result by more than 0.2 per cent.

The engines used in the power house are three Ball & Wood compound-condensing engines, 26 in. by 52 in. by 36 in.

The air compressors are two compound Laidlaw-Dunn-Gordon compressors, the steam cylinders of which are 12 in. and 21 in. in diameter respectively, the air cylinders 11½ in. and 24 in. respectively, the stroke 24 in. The steam from all of these is condensed in an Alberger barometric condenser equipped with a dry-vacuum pump and the circulating water supplied by a direct-connected centrifugal pump driven by a synchronous motor; an engine-driven cir-

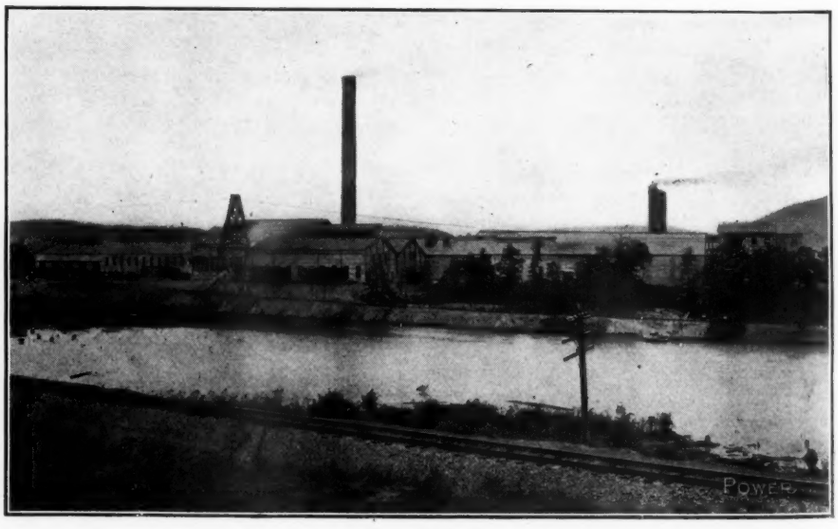

FIG. 1. VIEW OF THE CRESCENT PORTLAND CEMENT CO. PLANT SHOWING RESERVOIR

culating pump and a second dry-vacuum pump are installed as reserve.

The water from the condenser flows about 50 ft. through a tile pipe into the east side of the reservoir about 100 ft. from the north end. A dike was built south of this inlet to the reservoir ex-

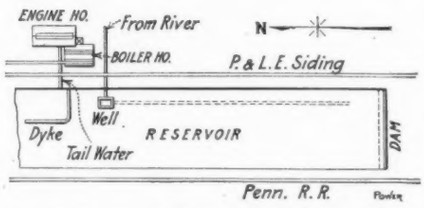

FIG. 2. DIAGRAM SHOWING 6½-ACRE RESERVOIR AND CONNECTIONS

tending about 50 ft. toward the center of the reservoir and then north nearly to the north end. This compels the circulating water to flow up and around the end of this dike and down toward the bottom of the reservoir to within 6 ft. of the dam. The intake water for the boiler feed and condenser is drawn from this well so that the water must flow up through the concrete tile pipe from the bottom of the reservoir at its deepest point. While water is being pumped from the river, there is a flow south through this tile pipe and when not pumping, the water is drawn in the opposite direction through it.

The average horsepower developed in the engines during the 21 days of these tests was 2446. Incidentally, it may be stated that there was an average of 3062 bbl. of cement manufactured per day during the same test, or 1 bbl. of cement for 0.8 hp.

The results of the tests during these three weeks are as uniform as could be expected; the heat lost per square foot of surface being slightly less per 1 deg. difference of temperature in cold weather than in warm weather. This difference

TEST OF HEAT RADIATION FROM SURFACE OF CONDENSER WATER RESERVOIR AT PLANT OF CRESCENT PORTLAND CEMENT CO., WAMPUM, PA.

Area of reservoir, 288,000 sq.ft.; average depth, 5.36 ft.; capacity 1,543,680 cu.ft.=96,480,000 lb.

Date of Tests	Week ending May 7, 1911	Week ending July 12, 1911	Week ending Nov. 27, 1911
Amount of water pumped from river, lb.	10,458,956	29,050,875	4,648,140
Average temperature of river water, deg. F.	57.5	77	36
Average temperature of intake to power house, deg. F.	72.75	91.43	61.71
Average temperature of tail water from condenser, deg. F.	101.36	129.43	90.71
Average temperature of reservoir, deg. F.	87.05	110	76.71
Average temperature of air, deg. F.	51	78.43	33.3
Average difference of temperature between water and air, deg. F.	36.05	31.57	43.41
Change in temperature of reservoir during test, deg. F.	0.25	7	2
Three 26 and 52 by 36 in. compound condensing engines, hp.-hr.	397,807	411,320	426,936
Two 12 and 21 in., 11½ and 24 by 24-in. air compressors, hp.-hr.	46,536	46,536	46,536
Average vacuum at 30 in. barometer, in.	26.4	22.2	26.6
Average water consumed by engines, per hp. per hr., lb.	14.46	15.64	14.41
Average water consumed by compressors per hp. per hr., lb.	18.85	20.12	18.83
Steam condensed by engines, lb.	5,752,289	6,433,045	6,145,148
Steam condensed by compressors, lb.	877,204	936,314	876,273
Latent heat of steam condensed, lb.	1024.7	1007.1	1026
Heat delivered to reservoir by engines, b.t.u.	5,894,370,000	6,478,720,000	6,304,922,000
Heat delivered to reservoir by compressors, b.t.u.	898,871,000	942,961,000	899,056,000
Heat to raise river water to average temperature of reservoir, b.t.u.	309,062,000	958,679,000	189,226,000
Heat given up or retained in reservoir during test, b.t.u.	24,120,000	675,360,000	192,960,000
Heat reduction in reservoir due to rain, b.t.u.	21,630,000	56,700,000	46,200,000
Heat absorbed by air and evaporation during seven days, b.t.u.	6,438,429,000	5,730,942,000	6,564,509,000
Heat absorbed by air and evaporation per sq.ft. of surface, seven days, b.t.u.	22,356	19,899	23,495
Heat absorbed by air and evaporation per sq.ft. per hr., b.t.u.	133.1	118.4	139.8
Heat absorbed by air and evaporation per sq.ft. per hr., per 1 deg. difference b.t.u.	3.69	3.71	3.22

dam, a distance of about 1100 ft., before it reaches the intake to the power house.

Water to supply the reservoir is pumped from the river by a centrifugal pump directly connected to a 150-hp. motor. The pump delivers an average of 2324.25 gal. of water per minute and it is found that about 8 hr. pumping per week is sufficient to make up for the evaporation and seepage in the reservoir. The water from the river pump is delivered into an open well situated on top of the plateau where the mill is located. It flows by gravity from this well through a 24-in. tile pipe into another concrete well located in the reservoir about 800 ft. north of the dam. From this well it flows through a No. 24 tile pipe laid on the

is undoubtedly due to an increased amount of evaporation during the warmer period.

The average humidity for the different weeks during which the tests were made was 58.5 per cent. in May, 62.3 per cent. in July and 71.2 per cent. in November.

It appears from the tests that under ordinary conditions, in the northern part of the United States with engines using 15 lb. of water per horsepower-hour and a vacuum of 26 in., a reservoir having a surface of 120 sq.ft. per hp. would be ample for cooling and condensing water.

The United States, Great Britain and Germany produce more than 80 per cent. of the world's total supply of coal.

Nugent Shaft Oiler

The latest oiling device brought out by William W. Nugent & Co., 220 to 222 West Huron St., Chicago, Ill., is shown herewith. It consists of a pump, can and a nozzle long enough to reach the shaft hanger to be oiled. The operator con-

NUGENT HAND OILER

trols the amount of oil used and may deliver a drop or a teaspoonful, or such quantity as may be necessary.

This oiler does away with the necessity of using a ladder, saves time and eliminates the danger of accidents to the man caring for the bearings.

Beware the blandishments of the scientific management expert who can look at the tongue of your wagon, feel the pulsation of your boiler-feed line, take the temperature under your collar, and prescribe offhand a sure-cure system, whose principal principle is "change everything."—*Chained Lightning.*

Keys and How to Remove Them

By George Rice

A man tried to remove a steel key from a crankpin and shaft by striking the arm with a hammer. He had previously tried to remove the key by the common method of driving it back, but had failed. He had also poured oil on the parts and tried other means to free the obstinate key. Then he lost his temper. It does not do to get impatient with keys, as they are pretty sure to hold tightly when driven correctly for that is what is expected of them. Nevertheless, this man sought to remove the key by banging at the parts with the hammer, but he had not delivered many blows when the cast-iron arm broke as shown at *A*, Fig. 1.

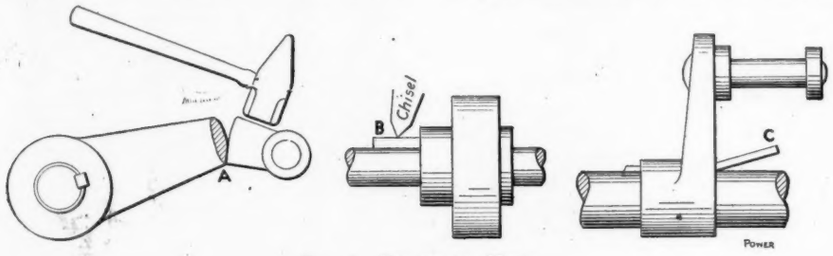

Fig. 1. Removing Keys

Another man used the sharp edge of a cold chisel on the part of the key extending beyond the hub, as at *B*. Consequently the edge of the cold chisel was sunk well into the steel and the key was ruined when it was finally removed.

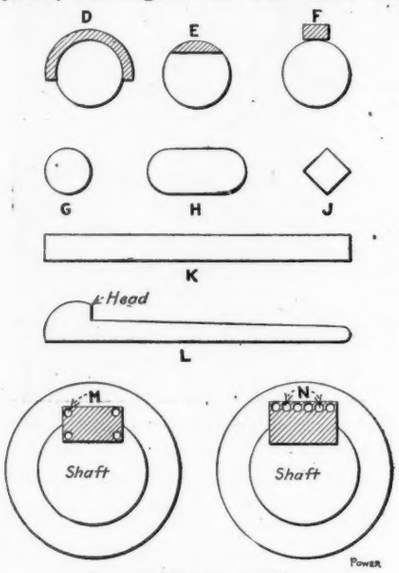

Fig. 2. Types of Keys

A common method of freeing refractory keys is to drive them through with a like key from the other side, as shown at *C*. This method is often used and is a good way of driving out stubborn keys when it is possible to get at the sides of the work. It will, however, be necessary to use a driving key of smaller dimensions than the keyseat; otherwise the driving key will bind so tightly in the seat that there will be trouble in getting it free.

Among the numerous types of keys in use is the half-moon-shaped key that covers about one-half of the shaft, as shown at *D*, Fig. 2. This key when once set is quite hard to remove. Then there is the key made to fit on a flat section of the shaft, like *E*, also the bothersome form of key *F* that is calculated to bind so tightly in the seat of the hub that the frictional contact with the shaft will cause the hub to hold firmly in place.

Still other forms are the round key *G*, the extended oval key *H* and the diamond-shaped key *J*. If the key has a head, *L*, the chances are that it can be pried from its seat with a cold chisel. If it has no head, *K*, and cannot be otherwise removed, drill it out by drilling the corner holes as at *M*. Instead of drilling holes at the corners of the key, holes are sometimes made along the upper side of the key as at *N*. The key is then easily removed.

Keeping Stray Oil Off Belts

By James Clark

In a plant having a number of pumps for high-pressure service, considerable trouble was experienced from the oil which would work out of the bearings and follow the shaft to the wheel hub to be thrown off by centrifugal force and land on the inside of the wheel rim. From there it would creep to the outside and get on the belts. Oil would also work out between the tight and loose pulleys and get on the belts in the same manner.

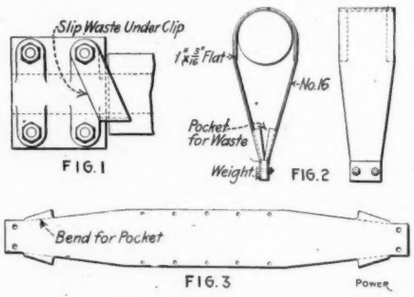

Fig. 1 Fig. 2 Fig. 3

To overcome the trouble caused by the oil from the bearings, some clips of No. 16 sheet steel were made and fastened between the two nuts which held the bearing cap, as in Fig. 1. The end of the clip was bent for holding a small bunch of waste against the end of the hub to continually wipe off the oil.

To take care of the oil from the loose pulley some oil catchers were made as shown in Fig. 2; Fig. 3 is a development in the flat. These were made of No. 16 sheet steel. The curved end which fits the hub was bent to a radius of about ½ in. larger than the hub and fitted with a strip of 1 x $\frac{3}{16}$ in. flat on each side. These strips are to prevent the catcher from coming in contact with the hub at the point where the oil works out; otherwise the oil would creep between the catcher and the hub to the spokes and down to the belts. The width of the curved end should be about ½ in. less than the distance between the spokes of the tight and loose pulleys, and the length from the center of the shaft to the end about 12 to 18 in., depending on the size of the pulleys. The other end of the catcher is fitted with a weight to prevent it from turning with the wheels; it also has a pocket to hold the waste. These devices are very simple to make and they completely cured the oil trouble.

City Smoke Ordinances and Smoke Abatement

The Bureau of Mines has just issued Bulletin 49, entitled "City Smoke Ordinances and Smoke Abatement," by Samuel B. Flagg. Some space on factors affecting smoke conditions in cities and the status of smoke abatement work in the United States introduce the pamphlet.

The exact form that the ordinance of any particular city should take can be decided upon only after a study has been made of existing local conditions. Certain features are desirable, however, and certain others are undesirable, and in the comment in the bulletin on the city ordinances some of the good and bad features are noted. Two specimen forms are presented, one adapted to the average conditions in a city of 200,000 population, and the other for a city of smaller size, ranging from 50,000 to 200,000 inhabitants. For the information of persons wishing to know the exact phraseology of some of the smoke-abatement ordinances, and especially those containing features of particular interest, the smoke-abatement ordinances of the cities of Chicago, Pittsburgh, Des Moines, Milwaukee and Los Angeles are printed at length, as well as the State act that applies to the city of Boston. Of these the Chicago ordinance is perhaps the most comprehensive and most complete of those in effect in the large cities of the United States. Its requirements apply particularly to the needs of a great industrial center where coals high in volatile matter are the chief available fuel.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Primer of Electricity

By Cecil P. Poole

The Electric Motor

The operation of an electric motor is due to the fact that a wire extending across a magnetic field will tend to move sidewise through the magnetic field if an electric current be passed through it. Reference to Fig. 92 will help the reader to understand this statement. If a current be passed through the wire *C* in one direction, it will move upward across the magnetic lines of force, unless restrained;

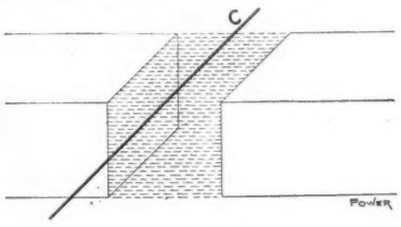

Fig. 92

if the current be passed through the wire in the opposite direction, the wire will tend to move downward.

Just why this is true has never been fully explained with scientific accuracy. One explanation, which is sufficient for ordinary purposes, is that magnetic lines of force under certain conditions act like rubber strings; when they are deflected from their natural path they try to pull back into that path, and thereby exert a force upon whatever deflects them. Moreover, if magnetic material

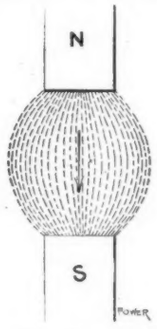

Fig. 93. Normal Flux

or another magnetic flux be located within the natural path of a set of magnetic lines of force, the latter will try to pull the material or the other flux into such a position as to reduce the "reluctance" (magnetic resistance) of their path to the lowest possible amount. Both of these properties enter into the explanation of the movement of a current-carrying conductor across a magnetic field.

Reaction between Magnetic Fluxes

Fig. 93 represents the passage of magnetic flux from one pole to the other of

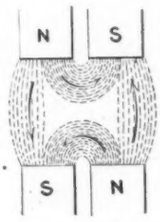

Fig. 94

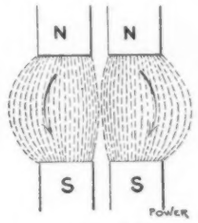

Fig. 95

Reactions between Two Magnetic Fluxes

a simple magnet (ignoring stray lines and leakage fluxes). If another magnet be located near the first one with its "north" pole alongside the other's "south" pole, the fluxes of the two magnets will unite to a large extent and the distribution of the fluxes will be somewhat as indicated in Fig. 94. Under this condition the two fluxes will try to pull the magnets together, because this would shorten the magnetic paths.

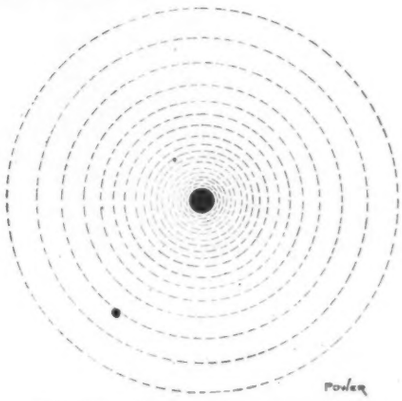

Fig. 96. Field around a Wire

If the second magnet be turned around so that the two "north" poles are alongside each other and the two "south" poles similarly placed, then the fluxes will oppose each other and the distribution will be somewhat like that represented in Fig. 95. The crowding of the fluxes in the space between their fields will tend to push the magnets farther apart, because that would remedy the deflection and shorten the magnetic paths.

Figs. 96 to 102 illustrate the elementary application of these principles to electric-motor conditions. As explained in an early lesson on the electromagnet, passing an electric current through a conductor produces a magnetic flux around the wire, as indicated in Fig. 96. Fig. 97 represents a conductor placed near the field of a magnet and carrying a current in such a direction that the circular flux has the direction indicated by the arrow. The circular flux, therefore, agrees with the magnet's flux where the two mingle, and the density in this part of the field is greatly increased. This crowds the

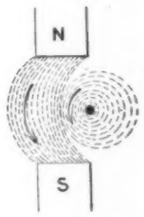

Fig. 97

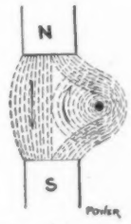

Fig. 98

Field Distortion by Current-carrying Wire

magnet's flux over to the left, and the lines of force, acting like rubber strings, tend to push the wire horizontally to the right and thereby restore the natural path, by the shortest route, between the magnet poles.

Fig. 98 illustrates the opposite condi-

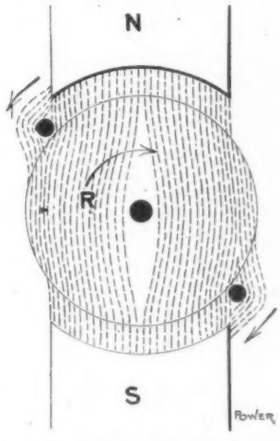

Fig. 99. Rotary Pull of Armature Wires

tion. The current in the conductor is in the reverse direction and the flux therefore circles around the wire in a clockwise direction. This forces some of the flux from the magnet out of the normal field and around the outside of the wire, and the tendency here is to pull the wire

further into the field because that will relieve the distortion of the main flux and shorten its path.

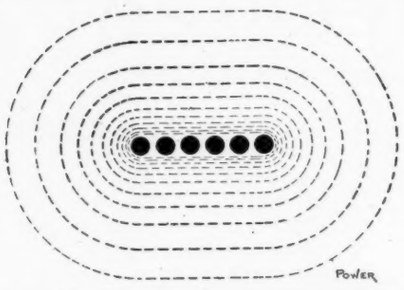

FIG. 100. FIELD AROUND GROUP OF WIRES

If the two wires be put on an armature core and are located as shown in Fig. 99, with current passing through them so as to produce the circulation of magnetic flux indicated by the small arrows, the

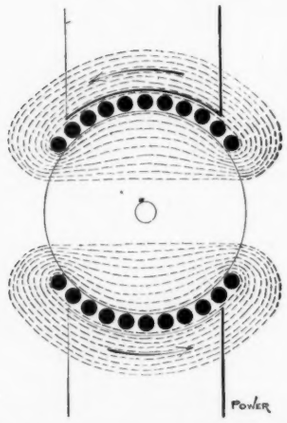

FIG. 101. FLUX DUE TO ARMATURE CONDUCTORS

condition represented in Fig. 98 will be produced in duplicate and the armature will be pulled in the direction shown by the arrow *R*. The step from this arrangement to a complete winding requires a little more elementary discussion.

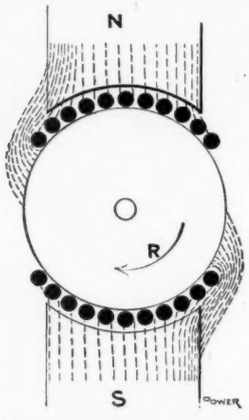

FIG. 102. FIELD DISTORTION BY ARMATURE CONDUCTORS

If several wires be placed side by side and currents be passed through them in the same direction, a magnetic flux will be set up surrounding the whole group, as indicated in Fig. 100. With two such

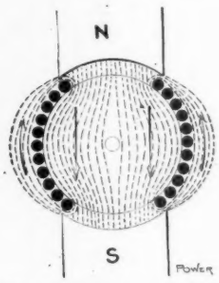

FIG. 103. POSITION OF MAGNETIC STABILITY

groups placed on opposite sides of an armature core and currents passing through the two groups in opposite directions a condition about like that illustrated in Fig. 101 will be obtained. So long as there is no flux set up by the field magnet the armature will remain stationary. If, however, the field magnet be energized so as to produce the polarity indicated in Fig. 102, the field flux will be distorted by the armature flux some-

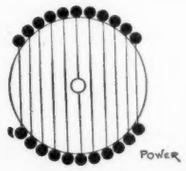

FIG. 104

what as shown and the armature will be pulled around clockwise until it reaches the position indicated in Fig. 103, where the armature flux can combine with the field flux without distortion.

In order to pass current through the conductors around the armature core in Figs. 101 to 103 in the manner described, they would naturally be connected to-

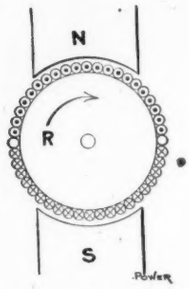

FIG. 105. FLOW OF CURRENT IN ARMATURE WIRES

gether, somewhat as indicated in Fig. 104, and the same current passed through the whole coil. With such an arrangement, however, the armature would turn no farther than the position shown in Fig. 103. To correct this defect, the armature core is provided with conductors all the way around the periphery and these are connected to a device called a "commutator" in such a way that the current passes through all the conductors on one side of the armature always in the same direction and through those on the opposite side always in the opposite direction, as indicated in Fig. 105, where the crosses signify current flowing away from the reader and the dots current flowing toward him. The action of the commutator will be explained fully in a future lesson.

TORQUE OR ROTARY EFFORT

The tendency of a motor armature to rotate under the influence of the magnetic fluxes is called "torque," which is measured in pound-feet (in English units); that is, pounds of "rotary" pull multiplied by the radius (in feet) at which the pull is exerted. For example, if the pull at the rim of an armature 12 in. in diameter were 100 lb., the torque would be

$$100\ (lb.) \times \tfrac{1}{2}\ (ft.) = 50\ lb.\text{-}ft.$$

If the torque is known, the rotary pull

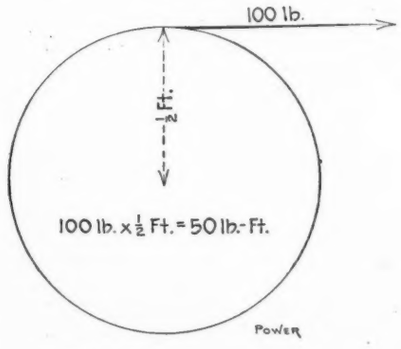

FIG. 106. TORQUE DIAGRAM

at the wires can be calculated from that and the armature radius, thus:

$$\frac{50\ lb.\text{-}ft.}{\frac{1}{2}\ ft.} = 100\ lb.$$

pull at the edge; see Fig. 106. This means the total pull of all the wires around the armature. If there were 100 wires, the average pull exerted at each wire would be 1 lb. The pull on the wires under the pole faces is greater than that on the wires outside, but that is not of much practical importance; it is the total rotary effort or torque that concerns the operator.

The torque of an armature depends on the number of armature wires, the current in each wire and the quantity of magnetic flux supplied by the field magnet. Multiplying the total flux passing between the armature and all of the magnet poles by the number of wires and by the current per wire, and dividing the final product by 852,230,000 gives the torque in pound-feet tending to rotate the armature. Expressed as a formula:

$$\frac{Total\ flux \times wires \times current}{852{,}230{,}000} = torque$$

in pound-feet, *not the pull in pounds.*

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Gas Engines at the Central Furnaces

By A. D. Williams

The plant of the American Steel & Wire Co., at Cleveland, Ohio, is known as the "Central Furnaces" and consists of four blast furnaces, the latest of which *D* was completed about 15 months ago. Power for the three earlier furnaces was furnished by a steam plant containing seven blowing engines and six engine-driven direct-current generators. In addition to this four gas-engine driven units, op ⁴ng on blast-furnace gas, supplied alternating current to the Cuyahoga and the Newburgh works of the company. This gas-engine installation has now been in operation about five years. With the addition of furnace *D*, however, two large gas-blowing engines—the largest in America—were installed to operate upon the gas from this furnace.

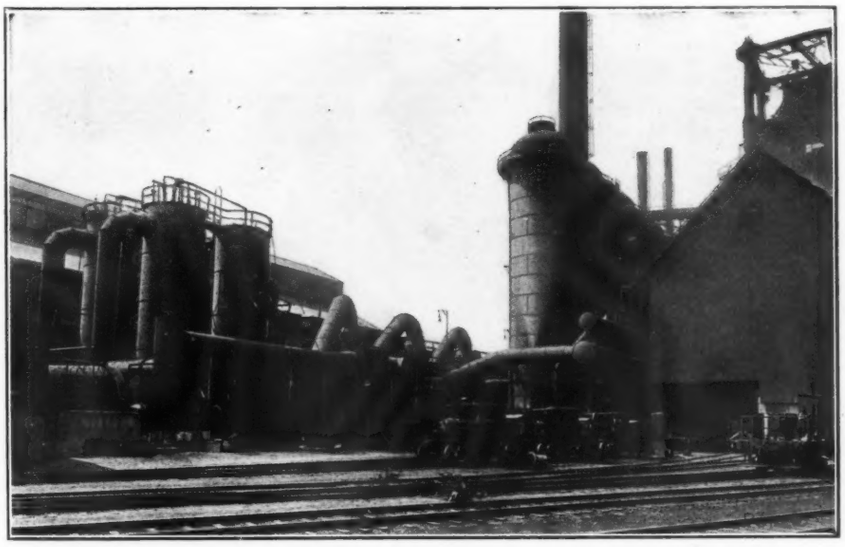

Fig. 1. Showing Blast Stoves and Gas-cleaning System of Furnace *D*

The general arrangement of furnace *D* is shown in Fig. 3. It is designed for an output of about 500 tons of pig metal per day, the entire output being run into ladle cars for transportation to the pig-casting machine or to the steel mills. The pig machine is used only for Sunday metal. Some of the ladle cars used can be seen in Fig. 1.

Gas-cleaning System

The furnace gases are taken off by four bleeders 3 ft. 9 in. in diameter connecting with four downcomers at a point about 18 ft. above the top of the furnace. (See Fig. 3.) On each side of the furnace the two downcomers unite in a single one and the two large downcomers connect at opposite sides of a primary dust-catcher 30 ft. in diameter by about 50 ft. high. This, together with the centrifugal dust-catchers, are located over a track and the collected flue dust is dumped into cars. This dust forms a part of the regular furnace burden.

From the primary dust-catcher the gas passes out at the top through a riser which makes a sharp turn into an 8-ft. main leading to the large centrifugal dust-catcher. Up to this point the gas passages are lined with 9 in. of firebrick as the temperature of the gases leaving the furnace is from 300 to 400 deg. F. There are one 14-ft. and two 12-ft. centrifugal dust-catchers arranged in series. A few furnaces have been equipped with a secondary dust-catcher, but the use of four is a new departure. They work on the same principle as a steam separator, differing only in size. The gas enters the upper part of these chambers on one side, the gas main forming a tangent to the annular passage. This imparts a whirling motion to the gas which then passes down through the annular passage and turns sharply upward through the inner shell, out the top and down to the tangential entrance of the next. The dust falls down the sides of the shell into the dust chamber, which is protected by a conical cover from the direct current of gas. This conical cover also serves to direct the gas upward to the outlet of the dust-catcher. The construction of this apparatus is shown in Fig. 2. At the bottom there is a counterweighted bell valve with an inclosing spout to concentrate the stream of dust. A 2-in. spray pipe in the spout serves both to cool the dust and keep it from being blown all over.

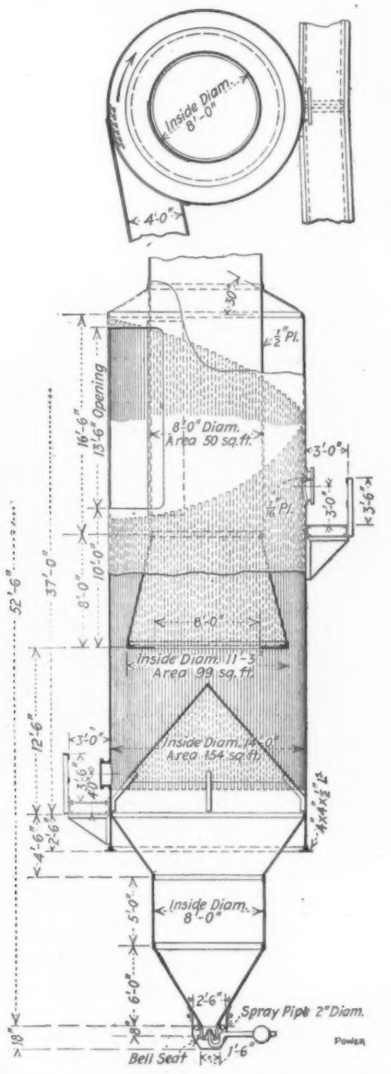

Fig. 2. Secondary Centrifugal Dust Catcher

After leaving the last 12-ft. dust-catcher the gas passes through a goggle valve which permits closing furnace *D* off from the gas system. The valve connections at this point consists of four

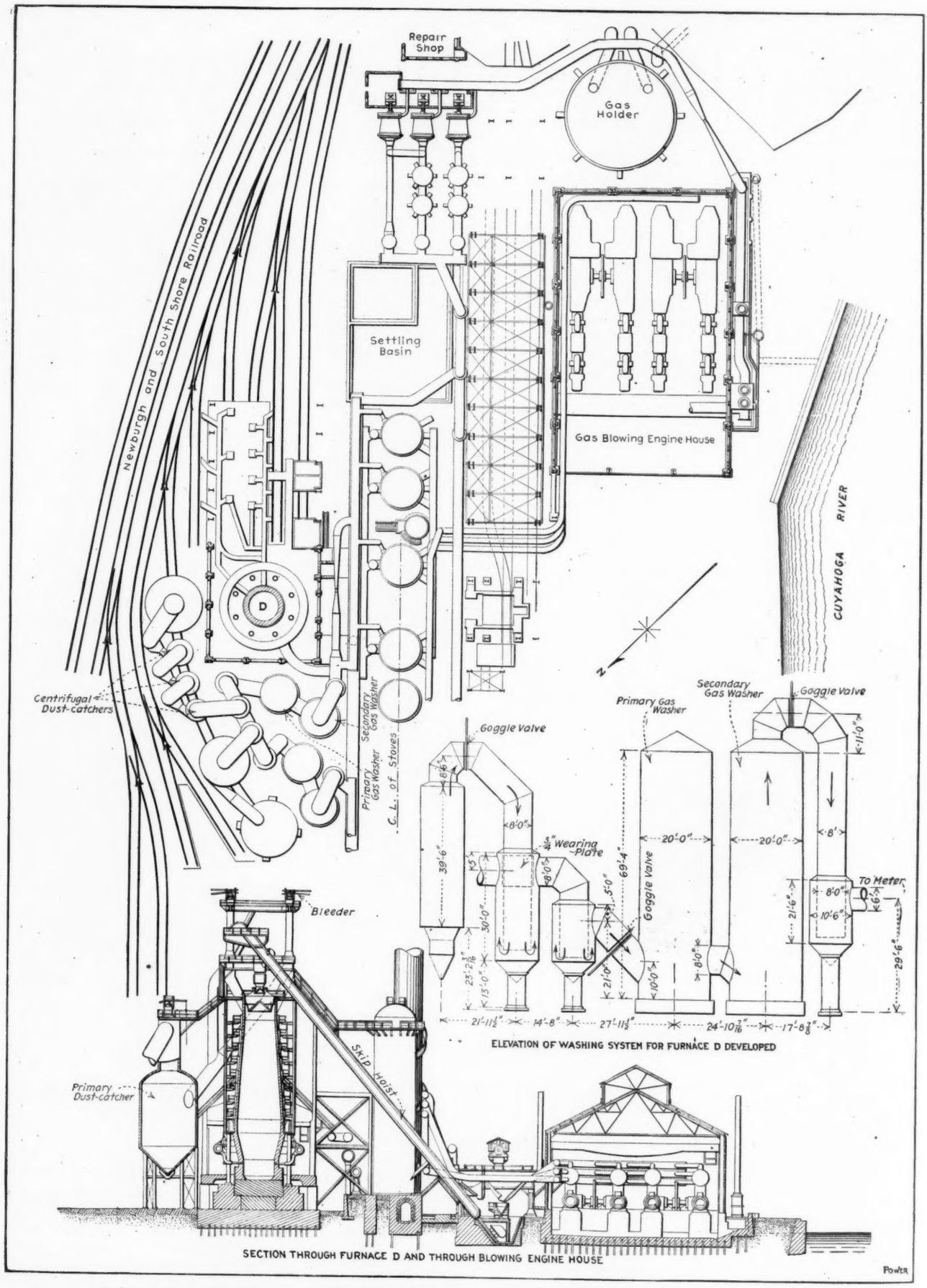

FIG. 3. PLAN AND SECTIONAL ELEVATION OF FURNACE *D* AND BLOWING EQUIPMENT AND DEVELOPED ELEVATION OF WASHING SYSTEM

water-seal valves and five goggle valves, so arranged that either furnace *C* or *D* can be cut off from the gas system, permitting either of the two sets of primary and secondary gas washers to be cut out for cleaning or repairs and the flow of gas from both furnaces can pass through one set of washers, or one set of washers may serve one furnace.

The primary gas washer, Fig. 4, is 20 ft. in diameter by 69 ft. high. The gas enters at the bottom and passes up an annular passage through a number of conical baffle-plates over which the wash water flows. At the top of the washer the gas turns downward through a central passage leading to the gas outlet. The wash water enters at the top, falling into a small distributing basin from which it flows on to the distributing cone through an opening around the bottom of the basin and by overflowing its edges. The distributing cone directs the sheet of water onto the baffle-plates over which it flows from baffle to baffle, falling through the ascending stream of gas. The water is then carried off through a trap or gooseneck and flows to a settling basin from which the flue dust can be recovered.

The secondary gas washer, Fig. 5, is the same overall size as the primary washer. The gas enters near the bottom and flows upward through a series of internal and external baffling cones and wire-net diaphragms and passes out at the top. Wash water is fed into the top by 32 inlets which turn horizontally in a trough encircling the top of the washer. The water overflowing the edge of the trough runs down an inverted cone and over a vertical wire-netting diaphragm through which the gas passes to a cone suspended from the inverted cone, thence over a second netting diaphragm, and so on, until it finally reaches the bottom and passes out through a trap to the settling basin. There are ten wire-netting diaphragms in this washer giving a large amount of washing surface.

After leaving the secondary washer the gas passes through a 48-in. venturi meter, arranged with a bypass for emergency use. Part of the gas is drawn off, after passing through the meter, for

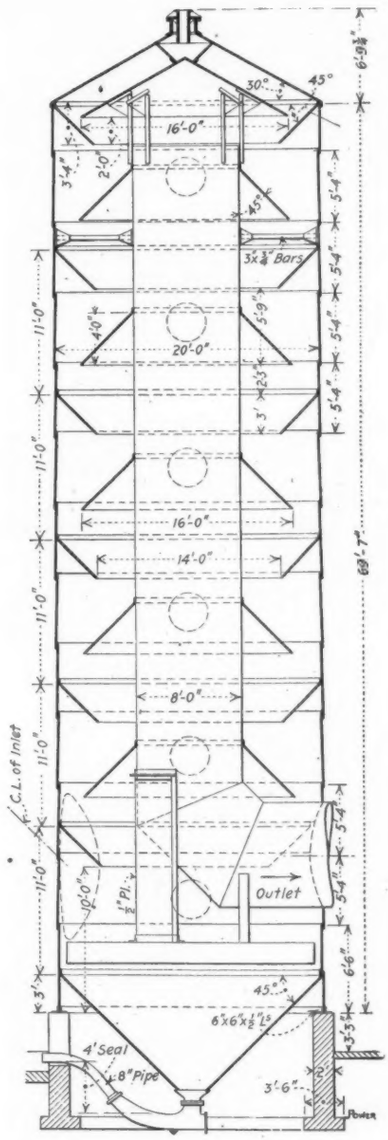

FIG. 4. PRIMARY GAS WASHER

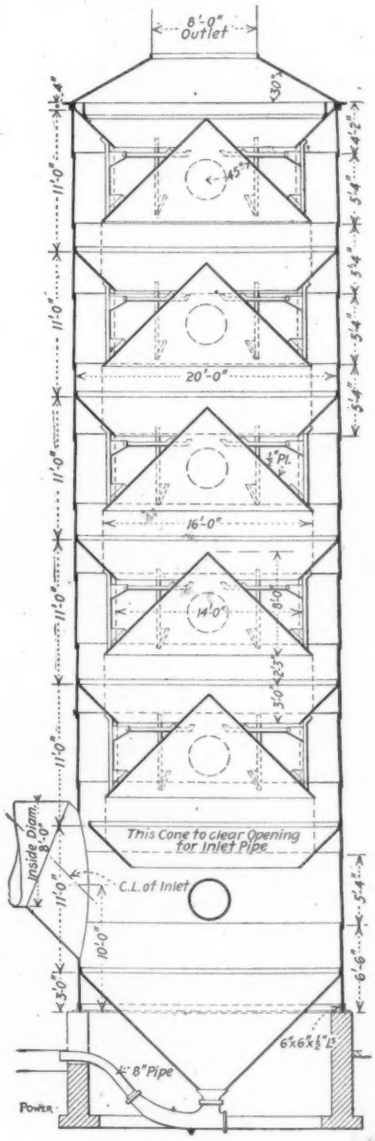

FIG. 5. SECONDARY GAS WASHER

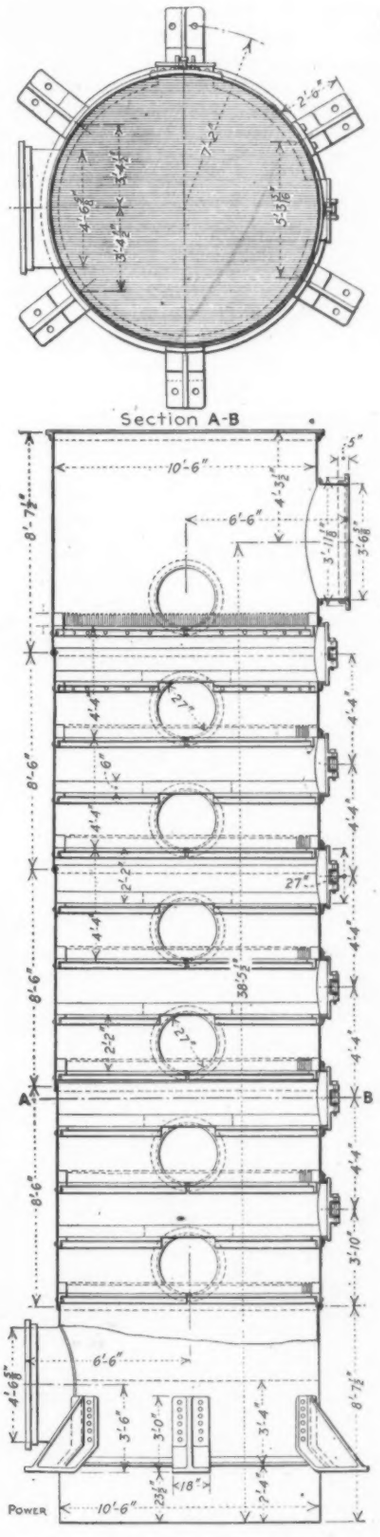

FIG. 6. ZSCHOCKKE GAS WASHERS

heating the hot blast stoves, and the remainder passes to a manifold thence through a water seal and a goggle valve to the baffle washer. This portion of the gas system is shown in Fig. 1. The gas enters at the bottom and passes up an annular passage obstructed by internal and external cone baffles with ¼-in. mesh screens in the openings between the baffles. It then passes down through the central gas passage to the outlet of the washer. Wash water enters at the top and falls into a distributing basin similar in construction to that used in the primary gas washer.

From the baffle washer the gas passes to the Zschockke washers, shown in Fig. 6; these are 10 ft. 6 in. in diameter and 43 ft. high. The gas enters at the bottom and passes up through a series of 13 wooden grilles, kept wet by the descending water, and leaves the washer near the top. Water enters through 12 distributing nozzles and leaves at the bottom. The wooden grilles can be removed through the clean-out doors.

Gas from the Zschockke washers goes to the Theissen washers, which are of the usual construction. These are operated by 150-hp. direct-current motors, but it is the intention to change to alternating-current motors as the constant load characteristics of the Theissen washers is particularly favorable for alternating-current operation. They receive the gas at a pressure of 11 to 16 in. of water and build it up to the holder pressure at which it flows to the gas engines.

The holder is 55 ft. in diameter with a 14-ft. lift and under normal conditions is kept full. From the holder the gas flows to the gas engines in the alternating-current power house and to the gas-blowing engines. The line to each engine house contains a 60-in. venturi meter which measures and records the amount of gas used.

The successful operation of the gas engines in this plant is largely due to the ample gas-cleaning equipment. Table 1 shows the average conditions of the gas for one month, during which period the furnace was working with Mesabe ore and flue dust comprising nearly 72 per cent. of the burden. Mesabe ore is extremely fine and frequently gives trouble in the furnace, even when there are no gas engines to be considered. In this case the gas carried 1.333 grains of dust per cubic foot at the entrance to the clean gas washer and 0.0185 grains of dust in the engine gas. The dust in the gas leaving the secondary dust-catchers was so fine that all passed through a 100-mesh sieve and the scum on the waste water from the gas washers passed through a 200-mesh sieve. This scum had the following composition: coke, 33.33 per cent.; silica, 15.02 per cent.; iron, 47.33 per cent. The dust taken from the gas engines had the following composition:

	Inlet.	Cylinder head.
Si	40.68	35.35
Fe_2O_3	22.03	18.70
Al_2O_3	5.70	9.50
CaO	10.21	7.68
MgO	6.40	4.20
Coke	12.34	23.48

TABLE 1. AVERAGE ANALYSIS OF GAS FOR ONE MONTH

	CO_2	O_2	CO	H	CH_4	N
Raw gas, per cent	12.7	0.36	26.3	2.7	0.22	57.5
Clean gas, per cent	12.7	0.36	26.2	2.8	0.22	57.6
Fine gas, per cent	13.0	0.40	26.9	2.9	0.22	57

Atmospheric temperature	34 degrees
Barometer	29.66 in.
Grains of moisture per cu. ft. in air	2.41
B. t. u. in engine gas, computed	101.1
B. t. u. in engine gas, by calorimeter	93.8
Flue dust in grains per cubic foot in clean gas washer	1.333
before baffle washer	0.980
after baffle washer	0.361
percentage removed and efficiency	58.45
after Zschockke washer	0.222
percentage removed	13.80
efficiency	31.66
after Theissen washer	0.0185
percentage removed	24.45
efficiency	90.47
in engine gas	0.0185
Moisture in grains per cubic foot in clean gas	26.65
Moisture in grains per cubic foot in engine gas	0.528
Clean gas temperature	162 degrees
Furnace burden, mesabe ore, percent	67.53
Furnace burden, flue dust, percent	4.34

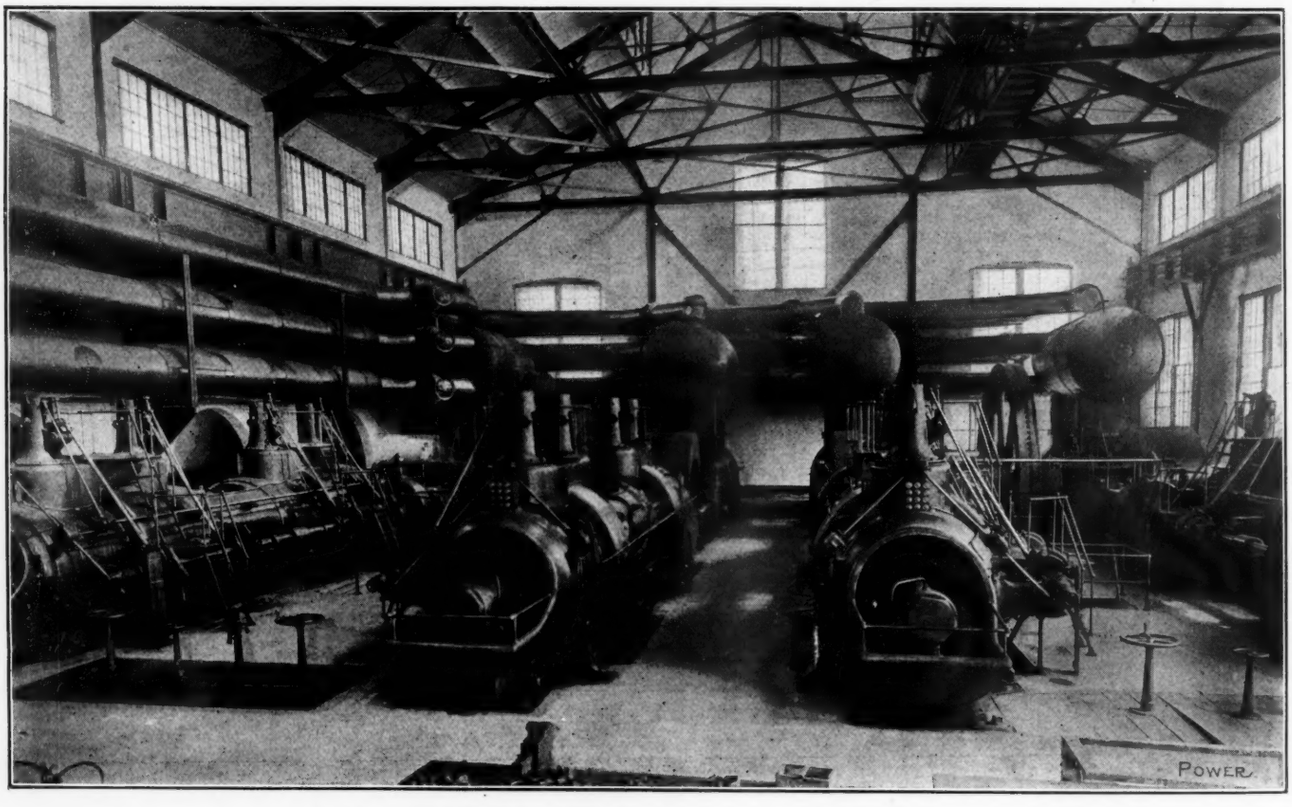

FIG. 7. GAS-DRIVEN BLOWING ENGINES AT CENTRAL FURNACES

BLOWING ENGINES

In Fig. 7 are shown the gas-driven blowing engines which consist of two twin tandem double-acting engines built by the Allis-Chalmers Co. having 44-in. gas cylinders and 60-in. stroke with air tubs of the Slick type, 80 in. in diameter. These engines have 23-ft. flywheels built

up of eight segments and weighing 137,000 lb. They are designed to operate against a normal blast pressure of 15 to 22 lb. and a maximum pressure of 28 lb. Each has a capacity at 60 r.p.m. of 40,000 cu.ft. of free air per min. and at 75 r.p.m. will deliver 50,000 cu.ft. per min.

A clearance of 2 per cent. is provided in the air tubs. The air-inlet ports have an area of 19.5 per cent. of the piston area and are arranged around the periphery of the tub. The outlet valves have an area of 17 per cent. of the piston area. There are four 18-in. valves in each end of the tub actuated by eccentrics on the main shaft of the engine; see Fig. 8. These valves open automatically as soon as the pressure in the cylinder exceeds the blast pressure and are closed positively before the air-inlet valve starts to open.

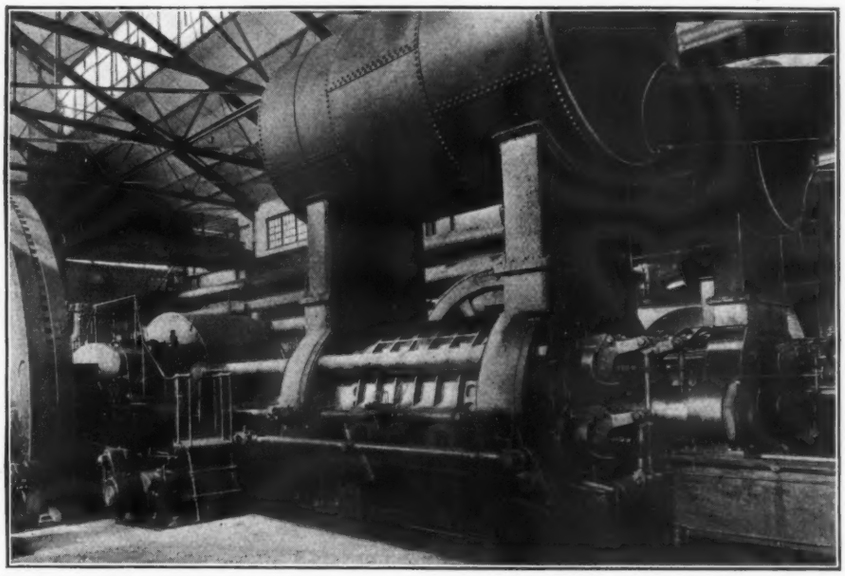

FIG. 8. AIR RECEIVER AND COMPRESSOR OR TUB

Above each air tub is a receiver of 1000 cu.ft. capacity from which the cold blast mains are taken off. There are three of these mains, one leading to furnace *D*, one to furnace *C* and one to furnace *B*, with gate valves operated by pendant hand chains from the floor. The cold blast mains are shown along the wall in Fig. 7. The arrangement of these mains permits the engines to blow any one of the three furnaces while a blast main from the steam-blowing engines to furnace *D* is provided for use when the gas engines are not in operation. The cold blast main connects with the four stoves in which the blast is heated and from which it passes to the hot blast main, thence to the bustle pipe from which it is taken off to the tuyere for the furnace.

The gas from the holder is brought to the engines by a 60-in. main which tapers to 48 in., a 24-in. branch being taken off to each side of the engines. From each side of the engines an independent 30-in. exhaust line leads to a muffler outside the building. These mufflers consist of a hollow cylinder 5 ft. in diameter by 12 ft. high with a 30-in. escape pipe about 50 ft. high.

Compressed air is used for starting the engines and a small compressed-air barring cylinder is provided for turning the engine over slowly. Air for this purpose is supplied by a two-stage air compressor driven through a Morse chain by a 50-hp. direct-current motor. The compressor has an automatic pressure con-

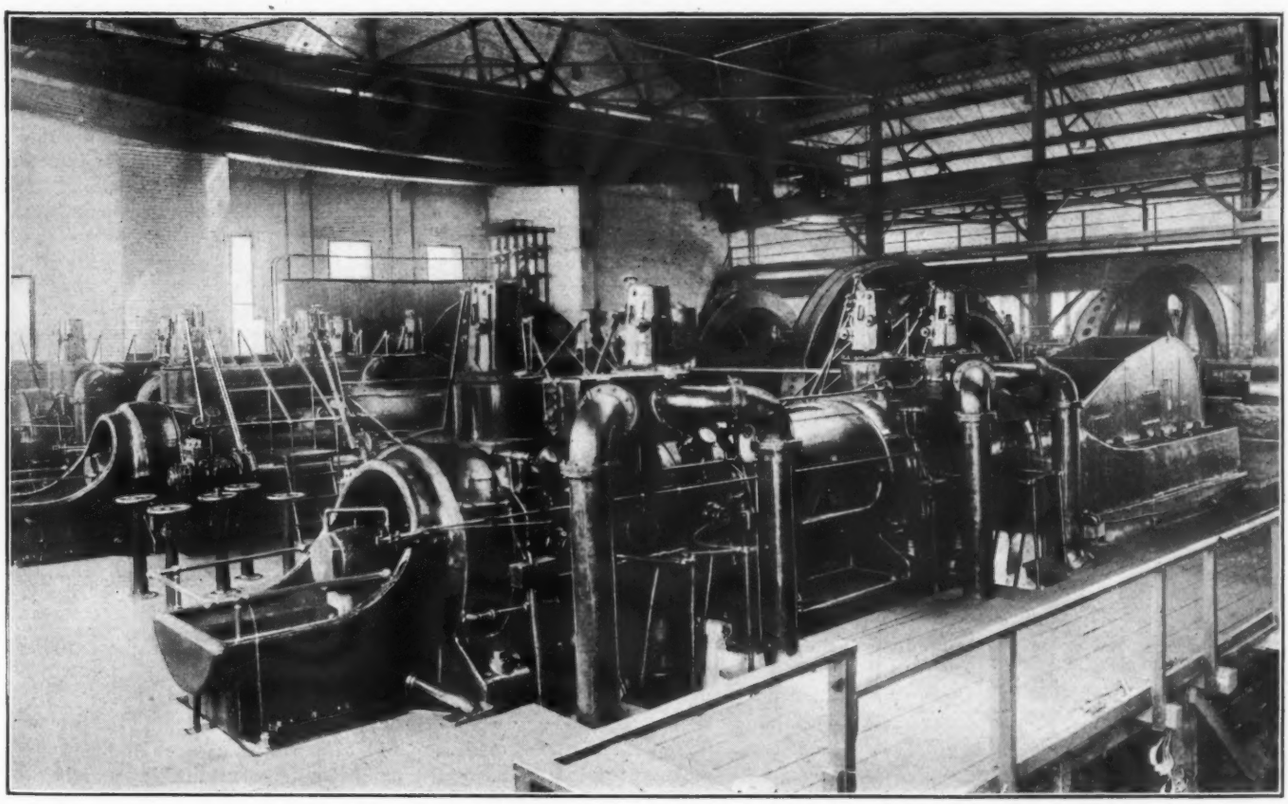

FIG. 9. GAS ENGINES DRIVING ALTERNATING CURRENT GENERATORS

troller so that the 250-cu.ft. air receiver is always kept full, and it has sufficient capacity to fill the tank in one minute.

A duplex ignition system is provided, there being two igniters in each end of each cylinder with a telltale lamp connected in series with it. A telltale lamp is also connected across the ignition circuits in such a manner that any break or current failure is immediately indicated and localized. The ignition current is supplied by a small motor-generator set.

The cooling water for the engines is drawn from the regular service supply of the furnaces upon which pressure is maintained by an 18-ft. water tower 101 ft. high.

Forced-feed lubrication is used, the oiling system being supplied from tanks supported in the roof trusses of the building and maintaining a static head of approximately 40 ft. Automatic feeders regulate the amount supplied to each bearing and the waste oil flows to tanks in the basement from which it is returned by pumps to the pressure tanks. The system is a duplex one, two pressure tanks being provided, with valve connections arranged to permit of shifting from one supply to the other. The pressure tanks hold about 200 gal. each.

These engines are close to the river and heavy piling was required in constructing the foundation. The site of the foundations was first inclosed with steel sheet piling and excavated, after which wooden piles were driven at close centers over the entire area with their tops cut off below the ground water level. The bottom of the excavation was carried below the point of cutoff for the piling a sufficient depth to give room for a cinder fill around the upper portion of the piles below the concrete mat which incloses the tops of the piles, making a raft upon which the piers supporting the engines were constructed.

Alternating-current Power Plant

The alternating-current power plant; see Fig. 9, contains four generating sets, each consisting of an 1880-hp. 34x42-in. twin tandem double-acting Allis-Chalmers gas engine direct-connected to a 1000-kw. generator. These engines have 18-ft. flywheels, each weighing 90,000 lb., in addition to the flywheel capacity of the rotating generator fields. There are two main bearings 23x42 in., each of which weighs 80,000 lb., the frames supporting these being the heaviest single pieces in the engines. The total weight of each unit is 740,000 lb.

The compressed-air starting equipment consists of a 4½x4½-in. electrically driven compressor drawing its supply at 90 lb. pressure from the furnace-air power lines and compressing it to 200 lb. in two 520-cu.ft. storage receivers. Two 1-kw. motor-generator sets convert the 220-volt direct-current supplied by the direct-current power plant to 90 volts for the ignition circuits.

The alternators are of the revolving-field type with 28 poles and deliver three-phase current at 25 cycles, 13,200 volts and 51.5 amperes per lead. Direct current for field excitation is obtained from either one of a pair of 100-kw., 250-volt, steam-driven units in the direct-current power house.

The lubricating system in this power house is the same as that in the gas-blowing engine house.

Practically the entire load on this plant consists of motors and the power factor is rarely better than 85 per cent., averaging 80 per cent. and occasionally dropping to 70 per cent. The total day load averages 3000 kw. and the night load 2000 kw. The gas consumption averages 237 cu.ft. per kw.-hr., and the oil consumption for the cylinders is 0.42 gal. per 1000 kw.-hr., and for other lubrication 0.22 gal. per 1000 kw.-hr.

The cylinder oil is recovered and used as engine oil. There have been no interruptions of service due to the gas engines, all service interruptions thus far being due to the opening of the circuit-breakers or to trouble on the line.

As previously stated, the alternating current is supplied to the Cuyahoga works and the Newburgh wire works of this company. Some of this energy will be used at the furnaces when the improvements now under way are completed, as it is the intention to operate some of the machinery upon which the load is nearly constant by alternating-current motors. The alternating-current plant can be tied in with the direct-current plant through a reversible motor-generator set for supplying direct current at times when the demand for it is in excess of the generating capacity and the direct-current plant can carry the alternating-current load at times of light demand.

CORRESPONDENCE

Ignitor Points

In looking over the numerous gas-engine journals, I noticed several advertisements, calling attention to the merits of different kinds of composition metals for gas-engine ignitor points, of the make-and-break type.

I have tried several, and found them good, bad and indifferent; my old standby is machine steel. I have used it for several years on a 600-hp. and a 300-hp. engine with good success; also it is much cheaper.

We keep all the old electrodes, cutting them up in the lathe to suitable points. The holes in the electrodes are then reamed slightly taper, and made standard. We can then make up a quantity of points at a time, and keep them in stock. It takes but a few seconds to punch out old points and replace them with new ones, when the old points become too short.

The points are made about ⅜ in. in diameter on the working face, and as before stated, are made slightly tapered, so they rivet up to a good tight fit in the electrodes, insuring good contacts.

On some ignitors, we make fixed electrodes with no point; just machining the exposed end round but eccentric with the shank, so that a slight turn of the electrode will take up wear and keep the contacts at proper distance.

Again, nearly all gas engines of the better class have bronze bushings in the ignitor body in the outside end, so as to be able to take up wear of the movable electrode. We bore out the ignitor bodies, so that the bushings can be made of ¼-in. brass pipe. These bushings will last a long time. The outside of the bushing is machined to a nice driving fit, the inside is bored out slightly small, and after driving the bushing in place, can be reamed true from the opposite end, and with a small drill the oil hole is put through. To remove the old bushing, tap out with suitable size tap, using a capscrew, nut and washer to draw it.

C. A. Stephenson.

Elko, Nev.

Rating of Gas Producers

The rating of gas producers in horsepower has been abandoned by most manufacturers, as there is no definite relation between the capacity of a producer and the power developed by an internal-combustion engine. The character of the fuel and the gas requirements of the engines affect the rating of the producers.

The rating of producers by the diameter of their fuel bed and by the rate of burning the fuel has been adopted by some. This is the same as the rating of producers by the pounds of coal burned per hour and depends on the gasification of 10 to 15 lb. of coal per square foot of fuel bed.

While the method of rating producers by the fuel burned per hour is much superior to the horsepower rating, it is also somewhat indefinite. The commercial efficiency of a producer, or the ratio of the B.t.u. in the gas to that in the coal will vary within wide limits. Thus with a good anthracite coal 70 or more cubic feet of gas can be made per pound of coal and the commercial efficiency should be about 80 per cent., while with a low-grade bituminous coal it is usually less than 50 per cent.

A better method of rating producers seems to be in B.t.u. per hour. Thus a producer rated at 1,000,000 B.t.u. should be capable of supplying an engine of 100 b.hp. if the gas requirement of the engine is 10,000 B.t.u. per b.hp.-hr.

A. A. Potter.

Manhattan, Kan.

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Standardization of Ammonia Fittings

By R. P. Kehoe

This question is now being discussed by manufacturers with the idea of adopting a uniform standard as has been attempted with steam fittings. The movement was started last May at a meeting of the American Association of Refrigeration and a paper was read setting forth the advantages of standardizing dimensions and bolt centers of ammonia fittings. This paper appeared on page 741 of the May 21 issue of Power.

It is claimed that owing to the large variation in the different makes of such fittings, great inconvenience is experienced by users. It is further claimed that manufacturers also find this variation an obstacle in selling their goods to plants already fitted up with a competitor's fittings. The first claim is more important than the second, as the convenience of buyers should be a primary consideration in the betterment of conditions.

There are undoubtedly good reasons for such a step, but there are also equally good reasons in opposition to it. The requirements in the manufacture of ammonia fittings, the existing preference on the part of owners and operators of refrigerating and ice-making plants, and in fact all the conditions bearing on the subject, are entirely different from those surrounding the standardization of steam fittings. In the latter case the field is almost unlimited and the demand for ammonia fittings is a very small fraction in comparison.

The inconvenience now experienced by users is really of small extent. There are not more than half a dozen prominent makers and some of them carry a stock of fittings in various parts of the country. The use of refrigerating and ice-making plants will never be such that it will pay to maintain a stock in smaller cities and towns in which there are only one or two plants in operation.

For example, consider the State of Pennsylvania. There are hundreds of plants spread all over the entire state, but for many years to come the demand will not justify a large stock of ammonia fittings except in Philadelphia and Pittsburgh. Perhaps some may disagree with this statement; if so, let other cities such as Harrisburg, Reading and Altoona be included. The owner of a plant in Erie will still be able to buy fittings in Chicago or Milwaukee with little or no disadvantage.

When changes are being contemplated there is usually a little time to prepare and obtain any necessary fittings. If a sudden demand arises and a certain fitting is required immediately, the expense for a telegram and expressage is a small matter, as this contingency occurs so seldom.

Machine parts, especially those subject to constant wear and motion, often break and show unexpected signs of giving out. These must be obtained far more quickly than ordinary fittings and yet hundreds of owners located a long distance from any manufacturer suffer little inconvenience even from this source.

In the United States there are about 5000 plants of from 25 to 2000 tons or more daily refrigerating capacity. There are many thousands of smaller plants. For 30 or 40 yr. there will be a demand for existing sizes from these plants in spite of the most earnest efforts to promote a standard. Some manufacturers will no doubt find it to their interest to foster this demand. In any event it will be necessary to continue the production of present sizes to an almost indefinite period. In the meantime it is very probable that new methods of making joints will be introduced and all the effort spent on standardization will be wasted.

Since a maker's individuality will be lost in the production of a universal standard of fittings, the tendency will be to make these as cheaply as possible. High-grade material may receive some credit, but in the general run of trade, the cheapest material will usually have the same consideration. It is difficult to determine the quality of cast iron, semi-steel, etc., at a glance and only a careful comparison may discover the difference.

As already stated, the production of ammonia fittings at present is almost entirely from the factories of half a dozen large manufacturers of ice-making and refrigerating machines. These fittings have been developed by years of experience and the closest application to a line of work which is known to be very special and exceedingly difficult to master. The flanges, fittings and valves form a very important part of every equipment. Practically all refrigerating work, whether it be in an ice-making tank or in the auditorium of a public building is performed by ammonia or some other medium circulating in coils of pipe.

Each refrigerating system must therefore have many fittings and these are supplied and installed by the makers under strong guarantees. Such an equipment must be carefully put together and nothing but proper fittings can be used with success. Some of the best grades of fittings have been in use for 20 or 30 years and show no sign of wear. Ammonia will not corrode iron or steel and if such pipe work is painted occasionally it will not wear out. Very seldom are ammonia lines altered or broken into, and in fact blanked openings are usually provided for future additions to avoid the necessity of making alterations in existing mains.

The present movement has not been instituted by ice-machine manufacturers, but by manufacturers of steam fittings. Like all other manufacturers when "standardization" is suggested, they concede its advantages and will endeavor to agree upon a proper basis. It is a good thing, but can be carried to an extreme. The result in the present case is very doubtful. Since manufacturers of ice machines will find it inadvisable to give up their present standards, it will probably mean still another set of standards for different types of fittings, which instead of simplifying conditions will add to the variety. In this event the stock on hand of each individual type and make of fittings will no doubt be proportionately reduced. The user will then be less able to count on quick deliveries than he is at present.

It should also be borne in mind that about 80 or 90 per cent. of ammonia fittings are installed or used in constructing new equipment by the manufacturers themselves. New plants and the largest part of alterations and additions are contracted for to be made up and completed by the builders. Only a comparatively small part of such work is put together by users.

Manufacturers are compelled to guarantee their apparatus, piping and fittings for at least a year. Needless to say, every part is usually of ample strength for the purpose. The reputation of the makers depends on the durability and satisfactory operation of their plants. They cannot afford to take the chance of furnishing flimsy fittings. The material may be a cheap grade and the design may be inferior to others, but the dimensions must be ample to provide sufficient strength for at least a reasonable period of wear. In the effort to overcome com-

petition, fittings may be made as cheaply as possible, but ice-machine builders must be careful to sustain their reputation and poor fittings may lose the sale of large plants.

The claim that builders find it difficult to sell their goods where a competitor's fittings are in use, has little foundation. In fact, large users as a rule have no objection to different makes of fittings in the same plant. If it is a consideration it is usually a minor one. When additions are made the connections to the system are a small detail and the new equipment can have entirely different fittings without inconvenience.

Standardization has done much in developing many lines of manufacture and is almost always embraced as a great benefit. Manufacturers hesitate to oppose it because their motives may be questioned, but the fact remains that in this instance a good principle may be adopted where it can avail nothing.

On the whole, when everything is considered, the question of standardization in the present instance offers no benefit to user or manufacturer. The former would probably have a larger variety to contend with and slower deliveries, while the latter would suffer a heavy expense for patterns and the necessity of tying up more capital in the stock of present standards and also a new one. The only gainers would be manufacturers of steam fittings who desire to enter the field. This may be considered an advantage which might introduce cheaper fittings, but the characteristics and improvements of ammonia fittings can only be developed by those manufacturers who are making a special business of ice-making and refrigerating machinery and are compelled to meet the changing requirements from day to day.

CORRESPONDENCE

Making Calcium Chloride Brine

Mr. Anderson's article on preparing calcium-chloride brine, page 682, Nov. 5 issue, is interesting inasmuch as he goes to such immense trouble to keep impurities out of the brine. I have used calcium-chloride brine at times and never have I seen a case in any of the packing houses, where this brine is used, where so much care was taken for so little gain. We used a 6x12x4-ft. heavy-plank brine tank. The suction pipe from the brine pump entered over the side near one end, passing down to within 8 in. of the bottom, while the discharge pipe from the pump entered over the top of the tank near the opposite end, with an elbow attached to deflect the flow downward. The brine was made by piling the calcium chloride in great blocks in the tank under the discharge pipe, allowing the discharge from the pump to circulate over the calcium and gradually dissolve it. The finer particles are quickly dissolved and the specific gravity when up to 1400 or 1500 per hydrometer is strong enough so that the brine will withstand a temperature of 5 to 8 deg. below zero without freezing. Where an open tank is used the calcium brine will lose its strength very rapidly, and unless some calcium is constantly added or allowed to slowly dissolve in the tank there is danger, in case of an accident to the apparatus, of the brine pipes in the cooler freezing. The greater density of the brine the better, as a much lower temperature can be maintained in the refrigerators, if so desired.

I have not noticed any deposit in the brine tank which came from the calcium, although some scale, due to the corrosion of the pipes, accumulates. A suitable strainer on the end of the suction line will prevent this sediment from being drawn through to the pump.

Calcium chloride is not a very pleasant substance to get on the hands, and Mr. Anderson must expend much labor in preparing the brine as described. I have heard of some plants boiling a small quantity of calcium where it was desired to put the refrigerating apparatus into service without delay. I think that Mr. Anderson's system requires an excessive expenditure of time and labor. If the system above described is adopted it will save much hard work and possibly a freeze-up in case of accident.

R. A. CULTRA.

Cambridge, Mass.

Long Springs on Discharge Valves

In the plant where I am employed there are two steam-driven ammonia compressors. The efficiency of the machines had been gradually falling off and, although the load due to expansion of business had been increasing, this condition could not be held as the cause. The double-pipe coolers were carefully overhauled and the internal pipes renewed as they were heavily coated with scale and rust and badly pitted. Naturally we looked for better results, but the machines still failed to "deliver the goods." About this time a new condition developed. Machine No. 1 would do about the same work as before, but machine No. 2 "laid down" altogether. At first it was surmised that the machine had been allowed to become unduly heated and had probably developed a scored or cut cylinder. To relieve any doubt on this point the cylinder was opened up and the valves reground, although they looked to be in good shape. Trials for clearance between the collar on the valve stem and the guide web on the valve cage showed no defect. A caliper showed the cylinder to be a very scant $^1/_{64}$ in. larger in the center than at the ends. The rings were in good shape and the clearance all right.

The machine was put together again and cut in on the system, but so far no betterment of conditions could be noticed. In fact, No. 2 machine was to all appearances the same as before the overhaul. Meanwhile No. 1 was steadily failing. This time the chief made the discovery that the needles on the suction or low-pressure gages seemed to be acting in a very sluggish manner. This started another investigation, and eventually the facts discovered were these: The springs on the head, or discharge valves were just long enough to allow the valve-box cover to be pulled up snug, leaving the spindle spring almost, but not quite, coil to coil, thus restricting the discharge-valve opening to a very limited area. When the springs had been shortened $^3/_8$ to $^1/_2$ in. and the machine cut in again, the way that the brine began to fall in temperature can only be appreciated by those who have had similar troubles. The same trouble was found in No. 1 machine and immediately remedied. Trial runs showed that the machines had been restored to normal operation. The above case indicates that it is a good plan to inspect the springs on all machines. It may save a lot of trouble.

H. J. GEAKE.

Victoria, West, B. C., Can.

Practice and Science

At the meeting of the Cold Storage and Ice Association of Great Britain, the president, J. T. Milton, in his opening address referred to the statement of Sir Alfred Ewing that the steam engine in its early stages of development owed little or nothing to theory. In mechanical refrigeration the case is different. At every step of the process we find the influence of scientific ideas. No part of it has taken place, except under the direct guidance of physical science. The success in producing low temperature for commercial uses has been rendered possible only by the combination of scientific knowledge and the mechanical skill and experience of the practical engineer. It is the engineer with high scientific knowledge and great practical experience to whom we must look for the further progress that will surely come. It cannot be too well recognized that a theoretical knowledge of all the principles involved in refrigeration and in the preservation of foodstuffs dealt with by cold storage, must add largely to the usefulness and value of those whose business it is to give the unremitting attention required to successfully deal with the everyday duty of the refrigerating engineer.

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POWER

State Boiler Inspection

Nothing could show more forcibly the need for stringent laws governing the operation of steam boilers, than the many cases of criminal carelessness, negligence and ignorance, brought to light since the new boiler-inspection law in Ohio went into effect.

This law made it possible to inspect many boilers that were never inspected by anyone, competent or otherwise, and revealed conditions that were startling, to say the least.

It exposed many plants where boilers were in charge of either grossly ignorant men, who knew absolutely nothing about the explosive energy in boilers under pressure, or criminally careless men, who, though otherwise competent, were operating under conditions that they knew were violating all laws of safety.

If the public only knew in how many plants dangerous conditions are found and corrected by the inspectors there would be no peace for our legislators until all states had adequate boiler-inspection laws. Massachusetts and Ohio are the only states having such laws and enforcing them, although there are some cities in other states having their own.

Here is one example of what is being found by the inspectors:

A so called high-pressure heating plant carried from 40 to 60 pounds of steam pressure, used a reducing valve and returned the condensation with a Bundy trap. It contained an 80-horsepower boiler, with a three-inch lever safety valve. The owner of this plant operated the boiler and lived next door. To heat his own house he reduced the discharge of the safety valve from three inches to one inch and connected to the house-heating system. When he wanted steam in the house he held the safety valve open by putting a stick under the lever.

This man took pride in showing the inspector the advantages of using this method for getting just the right amount of steam to heat his house in any kind of weather.

Another example is one of criminal carelessness on the part of a competent engineer. This happened in a manufacturing plant having a boiler 60 inches in diameter of $\frac{5}{16}$-inch plate, with double lap seams, $\frac{3}{4}$-inch rivets on two-inch pitch, 67.5 per cent. joint efficiency, 25-foot grates, and a $1\frac{1}{2}$-inch pop safety valve set to blow at 100 pounds. The bursting pressure was 360 pounds, making the factor of safety 3.6. The boiler was twenty years old.

The engineer, when asked why he operated the boiler at that pressure and with a safety valve entirely too small, knowing the danger of operating under those conditions, advised the inspector that he had the best job in town and that, if he made a kick, he would get fired, so he preferred to take a chance and keep the job.

It is needless to say that at both of these plants the proper remedy was applied to safeguard the public from "the fools that are with us." What might have happened had there been no inspection can only be conjectured.

The Logical Unit of Power

Although the unit of the mechanical rate of doing work established by James Watt (the horsepower) is generally accepted as being the equivalent of 550 foot-pounds per second, regardless of locality, the actual work represented by one foot-pound really varies a trifle with the latitude and altitude; Watt's horsepower, therefore, is not a stable unit. For example, 550 foot-pounds at 45 degrees latitude and sea level represents the same actual work as 551¼ foot-pounds at the equator or 549¾ foot-pounds a mile above sea level at 60 degrees latitude; the difference being due to the variation of the acceleration due to gravity, or as it is commonly expressed, the attraction of gravity.

These slight discrepancies are not of great importance in ordinary power-plant work, but they are a nuisance when it comes to translating between mechanical and electrical units, because the watt

is the same at all latitudes and altitudes.

The United States Bureau of Standards has therefore adopted a fixed value of exactly 746 watts for the equivalent of one horsepower and put the mechanical equivalent on the sliding scale where it belongs. The mechanical equivalent of 746 watts at sea level and 30 degrees becomes 551.01 foot-pounds per second; at 45 degrees it is 550.28 and at 60 degrees 549.55 foot-pounds per second. At an altitude of 5000 feet the equivalent of a horsepower becomes 551.92 foot-pounds per second over the equator; 551.18 at 30 degrees latitude; 550.45 at 45 degrees, and 549.71 foot-pounds per second at 60 degrees.

The bureau advocates the kilowatt as the standard unit of power*; and its argument therefor is reasonable. Unfortunately, however, pounds and feet are tangible, physical units with which everybody is familiar, whereas the kilowatt seems rather theoretical or even imaginary to the nonscientific mind. One cannot see a volt or an ampere. In reality the kilowatt is more fundamental in character than the horsepower, because it is based on physical phenomena which have the same values at all points within man's reach. Scientifically, therefore, the kilowatt is the logical unit of power and practically it is just as easy of application as the horsepower. Moreover, its adoption would greatly simplify the conversion of mechanical into electrical terms and *vice versa,* which is of considerable importance in these days of heavy-duty electrical machinery and long-distance power transmission.

Pipe Lines in Power Plants

Pipe lines have been appropriately called the arteries of the plant. In large plants, especially those of office buildings, the pipe lines are very numerous.

Because serious leaks anywhere in any iine damage the building and material near them and also waste the medium which the line conveys, it is highly important that those responsible for the care of hte lines know where any particular line goes to, what it conveys and where the stop valves are located. Further, they should know where to quickly find the stop valve nearest the leak so as not to interrupt the supply to more rooms or apparatus than necessary.

In office-building plants, as in all others, the engineer is looked upon as a bureau of information of anything relative to the light, heat and power. The operating engineers usually have little to do with repairs to pipe lines throughout the buildings, this work being done by the "fitters." But when the latter fail to find a particular line the engineer is consulted—"he ought to know," is the universal conclusion. He should, therefore, take keen interest in the pipe lines, the changes made and those proposed.

Unfortunately, the engineers on the night watches are frequently handicapped in this respect. Changes are made in important lines during the day without their knowledge. This leads to serious mistakes and trouble, which would have been avoided if a written notice of the change had been posted where all might read it.

It is difficult, indeed, to get thoroughly acquainted with the pipe lines in the cellar or in one part of the cellar, but to acquire the ability to distinguish the various lines in the rooms or shafts of a many-storied building requires time and study and there is no short cut.

The chief engineer should insist that the engineers, oilers, pipe fitters, plumbers, etc., under him study the lines, and in addition he should select one "fitter," a man of good memory and judgment to specialize himself in this work. The man should be a steady worker and one likely to remain in the company's employ indefinitely. To assure this his wages should be commensurate with the value of his services. There should be no hesitancy in giving him such, as he must be occasionally called out of bed or kept on duty Sundays to direct emergency repairs. The responsibility for the care of, and the recording of alterations to lines should also be given this man.

When new work is being done, those in the plant should go over the ground with the steam fitter or plumber and make notes of the location of the valves and what they control. There is no better way of "learning the lines."

All of the foregoing should be done in addition to studying and keeping uptodate the usual directories of the pipe lines. The latter should be posted where all may have access to the information which they contain.

*Circular No. 34, recently issued.

World-beating Discoveries

Every little while some genius proposes to revolutionize power production by applying an entirely new principle. Shoemakers render ashes combustible by sprinkling on them a magic "dope." Dry-goods clerks solve the "problem" of perpetual motion, and book dealers increase the efficiency of a machine to over 100 per cent. by introducing a train of gears.

That engineers have not solved these problems is because they have become so steeped in the dogma of their profession that they are blind to new principles.

Now a company has been organized to produce liquid carbon dioxide from the products of combustion from lime-kilns, power-plant furnaces, etc. The gases of combustion are taken from the stack, cooled and washed and then separated in a centrifugal machine; the different gases separating because of their different specific gravities. The carbon dioxide is then liquified and sold primarily for use as a refrigerant.

This scheme can be extended to extracting free nitrogen and oxygen from the air. Without doubt also these "centrifugal separators" will be installed in every power plant, superseding the slow and costly Orsat apparatus.

An engineer who was consulted thought that gases when brought together would diffuse until intimately mixed and that their subsequent separation would be extremely difficult. The company regard this man as "bright enough but very bull headed." In coal mines carbon dioxide issuing from the roof drops to the floor, showing that gases separate because of the difference in their specific gravities. How the human race has managed to exist in the stratum of carbon dioxide that must envelope the earth (if the foregoing reasoning is correct), is a mystery.

The improvement which recent years have effected in the efficiency of the air compressor, is brought into sharp relief by the statement in a paper recently presented by George Barr to the Manchester (England) Association of Engineers, in which he mentions an old compressor which was replaced by a new one of four times the capacity, which it nevertheless took only the same amount of steam to drive.

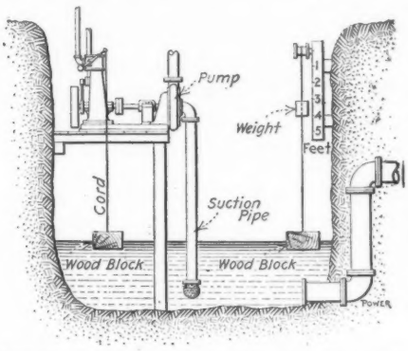
Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Automatic Control of Engine Driven Pump

Recently I ran a small engine driving a centrifugal pump used to remove water from excavations in which concrete work was being done. The engine and pump were on a platform in a very small sump pit. As the pit was always wet and difficult of access and as I worked nights, having to start the pump frequently to prevent flooding the newly laid concrete was very troublesome.

To avoid this inconvenience I bolted



ARRANGEMENT FOR AUTOMATIC CONTROL OF ENGINE CONNECTED TO SUMP PUMP

a lever to the handwheel of the throttle valve, put a weight on one end of the lever and a cable and block of wood on the other end. The wooden block floated in the water as shown. As the water rose, the throttle opened and did not close until the proper amount had been pumped out. I also provided a telltale that consisted of an ordinary large spool, cord and float as shown at the right of the illustration.

J. H. KELLY.

New York City.

Troubles with Superheated Steam

The troubles experienced in high-pressure plants operating compound engines with superheated steam have generally been blamed on the grade of cylinder oil used, the character of the iron in the cylinders or the piston rings.

I have had charge of several Corliss engines, of the vertical type, carrying steam at 150 lb. pressure and 120 deg. superheat that showed as high as $\frac{1}{16}$-in. wear in the rings in 24 hr., and the walls and pistons looked black and badly scored. A cylinder oil of a high grade, 600 deg. flash point, was used, but no amount of it would help matters. Graphite in various forms was used with no signs of relief.

After considerable studying it was finally decided that the trouble might be due to superheated steam getting in behind the rings when the valves opened, thereby causing an excess pressure. A set of rings, built in three sections with coil springs behind them, was made and a groove ¼ in. wide and ¼ in. deep turned in the face. Four ¼-in. holes were drilled in the bottom of the groove, through the ring, in each one of these three sections so that they could not become steam-bound. A set of rings was run in one engine for ten days and the cylinder opened and examined thoroughly. The walls and piston had smoothed up practically as good as new, and the rings showed very little wear. All the wearing surfaces had a good polish and the old troubles had disappeared.

All the engines were then equipped with these rings.

F. J. RAVLIN.

Chicago, Ill.

Cleaning Inside and Neglecting Outside of Boilers

In a boiler plant the parts most likely to be neglected are the external surfaces of the drum and tubes and the baffle walls of the boiler. It is comparatively easy to clean the scale off the inside of the drum and bore it out of the tubes, but another matter to get into the firebox and back chamber and, with a piece of pipe with a hook bent on the end, rattle the soot and ashes from the outside of the tubes. According to Professor Abady, a coating of $\frac{1}{16}$ in. of soot on the outside of the tube will cause a loss of fuel of 15 per cent., ⅛ in., a loss of 32 per cent., etc. The loss due to defective baffle walls can hardly be estimated, but it is very apparent that a defective baffle wall is expensive.

Last summer and again this summer the writer was called to inspect a battery of several water-tube boilers in an isolated plant in charge of an engineer supposed to be an expert. The inside of the drums and tubes were free from scale and could not have been in better condition, but on the outside of the tubes the soot and ashes were heaped up to a peak, and in some places were packed solid between the tubes. The tubes were blown two or three times a week, but the blower was not very effective. My practice when cleaning a boiler is to thoroughly clean the external surfaces first and stop up any air leaks that may appear, then go after the inside.

Economizers are fitted up with some form of an automatic scraper which keeps the tubes free from soot, and it seems to me that this idea could be applied with good results to the tubes of water-tube boilers, although boilers with vertical baffles would require two or three sets or scrapers. It is hard and slow to replace the baffle brick in some water-tube boilers, even with the recently invented tools, but I have found from experience that it pays in the end to be as particular in keeping the outside clean as the inside. Also that strict attention should be given to air leaks in the brickwork and around the doors. Lack of complete combustion has much to do with the amount of soot deposited on the tubes. When combustion is complete much less soot will collect on the tubes and a saving is made both in an increase of heat units due to more complete combustion, and also to more water evaporated per pound of combustible due to the absence of the insulating coating of soot.

J. C. HAWKINS.

Hyattsville, Md.

Unloading Coal on Bonus

In some plants the chief engineer finds it rather expensive to unload coal from cars by hand and transport it by wheelbarrows to the coal pile or pit. To those having charge of such work the following should prove interesting:

The laborers unloading coal from cars usually work slowly and the cost per ton of unloading is often very great. The cost per ton generally can be reduced by unloading the coal on a bonus system by which the men are amply compensated for the extra effort exerted in their work.

In some places the car is simply opened at the bottom and the coal dropped into the coal pit, in others the coal has to be shoveled into wheelbarrows and wheeled to the coal pit. It was in one of the latter places, where the coal had to be wheeled 20 ft. from the car to the pit, that the bonus system was tried very successfully.

Before the men were put to work on a bonus it took three laborers from a day and a half to two days to unload a 50-

ton car. The cost to the company was about $10, or 20c. per ton, the men receiving 18c. per hr.

Under the bonus system two men were given the job of unloading a 50-ton car. They shoveled out the coal and wheeled it 20 ft. to the coal pit in a total time of 19 hr. or about 23 min. per ton. The cost of unloading the coal was reduced to 14c. per ton and the men averaged about 30c. per hr.

This speaks well for the bonus system when laborers can increase their pay from 18c. to 30c. per hour.

W. L. MYLES.

Irvington, N. J.

Tank Collapses Under 14-in. Vacuum

As nearly as my recollections serve me, there was 14 in. vacuum on that tank the last time I passed it, the same being there by the order of Boss Kemist, who said the tank was guaranteed for 200 lb.

We were trying to force oil through the filters that were fast becoming plugged with waste, dirt, etc., and as they emptied into the oil tank, we were assisting the flow by applying the vacuum machine to the tank. At 10 in. vacuum the chief walked away in disgust, and at something above 14 in. there was a roar and the tank, one of the "common garden variety" type, closed up like a paper bag. The boss collapsed nearly as badly as the tank, because he was so persistent in his demand for a greater vacuum.

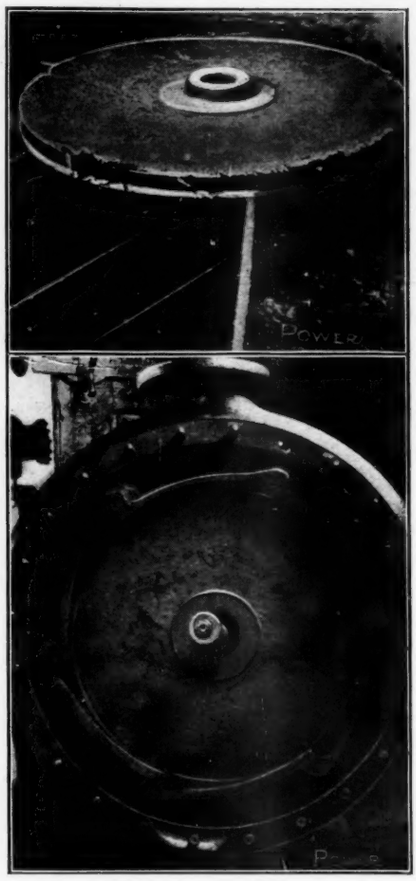
RICHARD PHOENIX.

New York City.

Corrosion of Pump

The illustrations show the corrosion of a 3-in. two-stage turbine pump, which we believe is due to electrolysis. This is one of two pumps which are taking water from a receiving cistern and delivering it into a storage tank of 3,000,000-gal. capacity, the high level in which is 164 ft. above the base of the pumps.

The water in the cistern is delivered from several deep wells by air lifts and double-acting deep-well pumps. Both of these turbine pumps are motor-driven, the motors being supplied with direct current at 240 volts, and they either run together, discharging into the same line, or separately, according to the demand. The motor driving the pump these photographs show, has for some time past been taking considerably more current than the motor driving the other pump, and just before the pump was shut down it was discovered that there was considerable current leaking where the leads entered the motor frame, which explained in a measure the much higher current consumption of this pump. The result is but vaguely indicated in the photographs. Both the runner and the entrance to the cross-over water connections into the second stage of the pump were badly pitted. I am unable to explain just why this action was confined to the part of the pump mentioned, but perhaps others may.



SHOWING CORROSION OF PARTS OF CENTRIFUGAL PUMP

Both of these pumps at times handle water which is very salty and which also contains some sulphur, but the other pump shows no such corrosion as does the one illustrated.

L. B. LENT.

Detroit, Mich.

Think It Over

The following actual happening illustrates better than anything else the value of a thorough system of power-plant records.

In a New England city of some 300,000 inhabitants, in the heart of the business district and within two blocks of each other are two department stores. Until recently each ran its own heat, light and power plant.

The engineer of one had been aware for some time that efforts were being made and persuasive arguments used by the central-station representatives to allow them to furnish light and power. As a matter of fact both engineers knew their companies were being approached.

The first engineer was called into the office and told of the central-station solicitor's offer and was shown the figures. "If you will wait a moment or two Mr. Blank, I will show you some figures that I think will interest you more than these." The engineer came back with the plant records on which were figured everything entering into the cost of production of a kilowatt-hour. Initial cost of installation, floor space, interest and depreciation, coal, oil, waste, lamp renewals, wages, and even removal of ashes. The central-station man nearly collapsed when the total showed a kilowatt-hour for a price far below his offer.

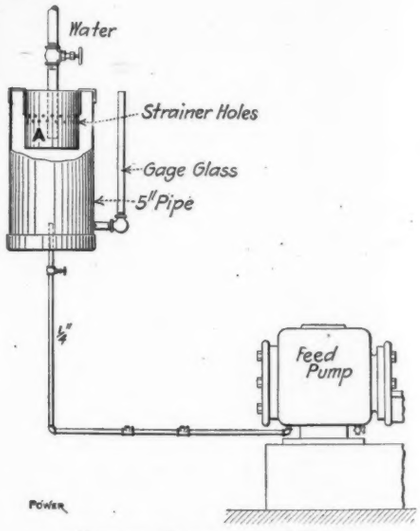
Neither he nor any of his kind have ever been seen around that plant since. I do not know what the engineer of the other plant has been doing, but at last report he was looking for a job, because that same solicitor got his firm's signature to a contract on July 1. The reason is obvious.

R. H. LYMAN.

Moosup, Conn.

Boiler Compound Feeder

The illustration shows an inexpensive apparatus for continuous feeding of boiler compound in connection with a pump drawing water from an open heater or other source under less than 5 lb. pressure.



BOILER COMPOUND FEEDER

The operation is as follows: Place the compound in powder or brick form in the bucket *A*, and turn on the water slowly (hot or cold). This will dissovle the compound and the liquid will overflow through small holes near the top of the bucket. When the tank is full open the valve in the ¼-in. pipe enough to empty the contents in 12 or 24 hr. as desired.

The ¼-in. pipe connects through two

checks into the drain opening on the water cylinder of the feed pump. Each time the plunger makes a suction stroke it draws in a small amount of compound and this amount increases with the speed of the pump.

If the water comes to the pump under too much pressure tighten the spring on the suction valve of that chamber, which will make the pump draw harder on the feeder. It is necessary to use two check valves *B* on account of grit getting under the valves, then one will usually be clean and hold back the water on the discharge stroke which would otherwise flood the feeder. Dry compound can be added at any time without stopping the feed and the usual mixing pail, funnel and spilling of compound are avoided.

A. KARREMAN, JR.

Grand Rapids, Mich.

Card Index System

Many ideas have been set forth in POWER relative to filing articles so they can be found readily when wishing to refer to them. While many of these ideas were good, none of them appealed to me as exactly what I wanted, consequently I tried, and am using one of my own. I drew up a sample card size 3x5 in. and had 1000 cards printed like those shown, for which I paid $1.60.

All matter pertaining to one subject,

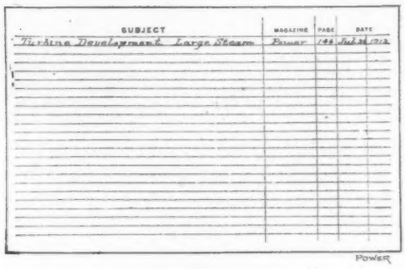


FIG. 1. SUBJECT CARD

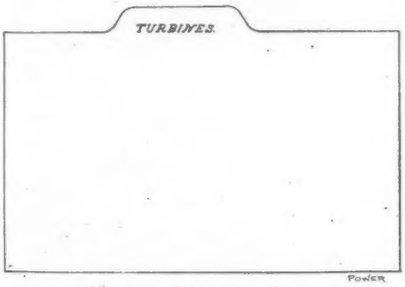


FIG. 2. INDEXED CARD

as turbines, is put on one card, as in Fig. 1. These cards are not indexed, but another set, Fig. 2, is used, which is blank except the index. These cards are all kept in a box made purposely for them, the index cards being placed directly in front of all cards on that subject. It is therefore easy to find the articles on any particular subject by referring to the date and page of the magazine mentioned on the card, no matter how long it has been printed.

I do not cut the magazines, but separate the reading matter from the advertising sections, and bind the former into books of convenient size, so that the page numbers are continuous. I have found this index a great time saver.

L. E. THOMPSON.

Medford, Mass.

A Knock to Locate

I have charge of a 60-hp. suction gas producer plant, the engine of which is belt-connected to a 30-kw., 2300-volt generator. The engine has a knock which I am not able to locate and would like to hear from interested readers in regard to the cause and remedy. The engine has a throttling governor that controls the mixture. The engine knocks while coming up to speed, but runs very quietly until a very light load is thrown on, then the engine knocks in one cylinder only, but this knock is in step with every other revolution of the engine. As the load increases, the knock becomes irregular up to about one-half load, after which the engine runs very quietly.

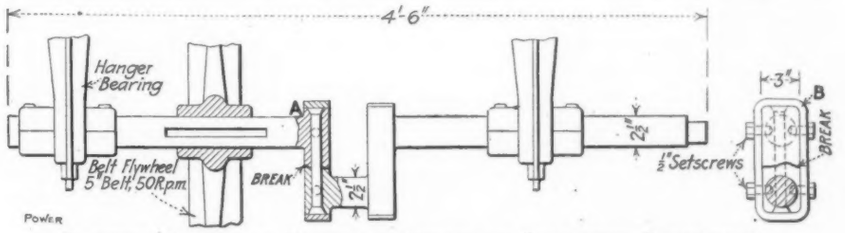
The crankshaft is in alignment and all bearings are taken up to a good working fit. The spark has about 15 deg. advance. The fuel used in the producer is coke.

P. F. ROBNETT.

Chouteau, Mont.

Air Pump Crankshaft Repair

The shaft in question drove an air pump through a long connecting-rod and being single acting, the badly arranged bearings and belt flywheel caused much unnecessary stressing. The break showed a bad flaw in the forging and the fracture was prematurely opened as the flywheel, which was originally keyed to the shaft with a flat key, worked up against the crank web at *A*. The first intimation of trouble occurred when the flywheel reached the floor 10 ft. below, accompanied by the pieces of crankshaft and the shaft hangers.



SHOWING CRACK AND MANNER OF REPAIR TO FRACTURED CRANKSHAFT

A repair was at once effected by clamping the two parts of the shaft together firmly and after setting them between lathe centers, getting them as true as possible, drilling a 1-in. diameter hole down through the web, a tool steel pin was driven in lightly and headed over cold. The sharp corners of the crank web were well rounded off and an oblong ring *B* of 2x⅝-in. iron was shrunk on. Setscrews were used to prevent the ring shifting.

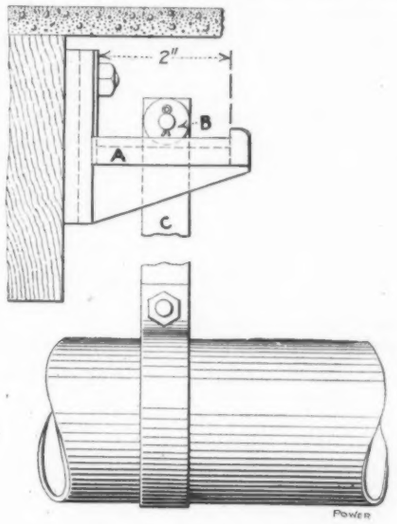
The hangers meanwhile having been set up, the shaft was replaced, and, although it was slightly out of true, it ran day and night for a month until a new shaft arrived.

J. MCA. HOWDEN.

Melbourne, Vic., Australia.

Expansion Pipe Hanger Bracket

While erecting an exhaust heating system in a modern concrete building, I had occasion to connect an 8-in. pipe line



EXPANSION PIPE HANGER BRACKET

about 175 ft. long running under beams at right angles to the pipe.

To suspend the line, taking care of expansion and contraction and avoiding bulky brackets or spools, I designed the expansion hanger bracket shown. The bracket *A* is a casting weighing 4½ lb., cast without cores; the rollers *B* have a travel of 2 in., and the suspension bar *C* also has a ½-in. lateral movement in a slot. This size bracket is suitable for 6-in. to 12-in. pipe with the hangers spaced according to the size of the pipe. The design of the bracket can be modified for pipe lines to run parallel to the beams.

GEORGE G. LENNIG.

Philadelphia, Penn.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Smoke Prevention with Automatic Steam Jets

In the Sept. 3 issue in an article under the above heading, J. A. Sweitzer referred to my article published in the Feb. 20 issue and took exception to my statement: "The rate of combustion depends on draft." He followed with this remark: "This is a very orthodox statement; if coal were a pure carbon it would be strictly true and with anthracite coal the rate of combustion does depend almost entirely upon the draft, but the statement emphatically does not apply to soft coal and especially where it is hand fired."

First of all the rate of combustion is the amount of coal burned per unit area of grate in a unit of time. In practice a unit of time is taken as one hour and a unit of area as one square foot of grate. The amount of coal which a fireman can shovel into a furnace is not limited by his physical ability or the coal on hand but by the amount he can burn economically. To burn coal economically requires a fixed amount of oxygen which has to be obtained from the atmospheric air and this oxygen must be uniformly distributed throughout the fuel bed, and the operation requires force. The force required to deliver air to the fuel bed and to distribute it is derived from the draft.

Draft is a pressure difference between the outside and inside of the stack; this pressure difference is created by heated air entering into the stack and as heated air has a greater volume than an equal weight of cold air, it weighs less for the same volume. This difference in weight causes the flow of fresh air from outside into the furnace and thence into the stack. The pressure difference, not the vacuum, does the work; therefore the rate at which air is delivered and distributed through the fuel bed and thence carried into and out of the stack is proportional to the pressure difference. The greater the pressure difference the more air will be delivered and better distributed and, therefore, more coal can be consumed. Oxidation of fuel becomes easy if the desired impinge of air against the fuel can be had and intimate mixture of volatiles and air can be obtained by arches or arches and steam jets combined. Every fireman knows this and regulates his draft accordingly, and no amount of sophism will convince him that he should close the damper if he wanted more steam or to burn more coal. From this it can be seen that the rate of combustion in any case, regardless of what the fuel may be, depends entirely upon the draft.

Further in the same article Mr. Sweitzer has quoted from the excellent work of the Bureau of Mines, Bulletin No. 26, describing how distillation takes place and what the products of distillation are, he concludes as follows: "From this discussion it should be clear that it is not the rate of combustion which depends on draft as Mr. Misostow states, but on the rate of driving the combustibles out of the fuel, an altogether different matter."

To burn coal it must be broken into, first, gas and fixed carbon. Carbon enters into combustion in very small particles, gases are broken into their elements—hydrogen and carbon. Hydrogen first liberates the carbon and enters into combustion with the oxygen and liberated carbon enters into combustion in its turn and forms CO or CO_2. Distillation being the preparatory stage in the combustion of coal, naturally bears a direct ratio to the rate of combustion, but it cannot be substituted for the rate of combustion, which means consumption of all fuel. The rate of distillation in coke and gas making, for instance, is entirely different from the rate of combustion and it has a very indirect relation to it.

In the same bulletin, quoted by Mr. Sweitzer on page 367, under the heading "Relation of pressure drop to rate of combustion and evaporation," concludes: "Thus one may logically conclude that the rate of combustion and the capacity of the boiler will vary with the difference of pressure between the furnace and the uptake." The difference of pressure referred to is draft.

Steam Jets

The difference between automatic steam jets and common steam jets is that one is shut off automatically and the second is hand operated. Mechanism which starts steam jets is sometimes actuated by fire-doors and closing is accomplished by some arrangement of weight and dashpot; in fact the most ingenous one I ever saw was operated by a damper regulator. The advantage claimed for automatic steam jets is that they save steam, that is, they use steam only when required while the common steam jets are turned on all the time; however, so far as their respective work is concerned one is no better than the other when properly installed.

Automatic steam jets are generally patented and the patentee naturally expects to be compensated, whereas common steam jets can be installed by any engineer. The drawback of the automatic steam jets is that they become autocratic and refuse to work, are more complicated, and as the fireman does not throw on the same amount of coal at every charge one adjustment is not satisfactory for all fire conditions. However, they may be all right, but most of the time they give trouble.

H. Misostow.

Chicago, Ill.

[The last sentence of Mr. Misostow's letter would lead one to believe that all automatic steam jets for draft production were subject to frequent failures of proper operation. This is not wholly true, for with proper care, the attendant need experience little trouble with the jets.

The chief trouble with automatic steam jets is the plugging of the steam nozzles with the alkaline impurities carried by the steam from the boiler. This trouble is easily overcome by pushing a wire into the nozzle while the steam is blowing through; the pressure will then blow out the particles as they are broken away by the wire.

When the nozzles are placed in the soot-pit and the latter is allowed to fill with soot or the sliding door of the pit is closed, the air supply is so reduced as to make the jets ineffective. There is no excuse for such troubles, however, as reasonable attention to duty would obviate them.—Editor.]

Comment on Pressure Chart

Although it is a little late, I cannot refrain from commenting on the steam chart shown by Mr. Seymour in the Aug. 13 issue.

The steam pressure varies from 120 to 130 lb., which is too much. If he cannot make the damper regulator work better than it does, I advise him to discontinue its use altogether and regulate the damper by hand. Steam charts that do not record a pressure variation of more than 2½ lb. in 24 hr. are common. Mr. Seymour should be able to obtain such charts. Again, the chart shows that the damper is closed about half the time.

I wonder what a CO_2 recorder would show if applied to his boilers. He should cut out some of the boilers or reduce the grate surface in them until his firemen will have to work harder to keep up steam if he wants to obtain economical boiler operation. He says the fires are cleaned three times in a 24-hr. run. I believe that. It merely shows that he has too many boilers in service; otherwise the fires would have to be cleaned oftener to keep up steam. I imagine that the fires must get quite thick after an eight-hour run, and that the amount of air that would get through the very thick fuel bed would hardly be enough to support good combustion.

If he will clean his fires at more frequent intervals, installing grates that will admit of easy cleaning, he can bank the 250-hp. boiler and have it standing by for emergencies and save coal. I mentioned that his dampers, and probably also the fan, were shut off half the time. The rest of the time more heat was being generated than the boilers could absorb and the gases were going to the stack at too high a temperature.

W. T. MEINZER.

Brooklyn, N. Y.

Unsafe Boilers

The article under this heading in a recent issue reminded me of some unsafe boilers I saw recently. We had loaned a pulsometer pump to a firm that was sinking its quarry deeper. After they had used the pump for a day or two, they called up the office and wanted a man sent up to start it, as they were unable to do so.

I went the next day and found the pump connected to a small vertical boiler of about 40 hp. No provision had been made for a throttle valve near the pump and no extra valves were in stock, but I found an old one on a water tank and connected it into the pipe. The steam line was in accord with the rest of the equipment, being old, rusty and leaking at every joint.

The fireman informed me that the boiler could carry 125 lb. and as the safety valve was blowing off slightly I started the pump, which, after a few strokes stopped.

Thinking something was wrong with the valves I opened the pump, but found everything in good condition. I was then informed that the steam had fallen to 70 lb., so telling the fireman to get a good fire going, I walked over to a small locomotive-type boiler that furnished steam for two drills just to see what it looked like. It was very rusty and as I approached I saw it was leaking at the girth seam where the shell joined the firebox.

There was no steam gage or water glass and I asked the fireman who came over to put on fresh coal: "What pressure have you got on this boiler?" "Me don't know," he answered, "Bime bye she pop," and sure enough it did as soon as a drill was stopped.

Opening the fire-door disclosed a bad bag in the crown-sheet. The joints around the stay-bolts as well as the flues were leaking and in very poor condition generally. How they ever kept a good fire in the furnace was a mystery to me, even though the blower was working to its full capacity.

The lower try-cock showed water when opened but the upper ones were tightly plugged. This aroused my curiosity as to the condition of the rest of the equipment and I walked back to the boiler that supplied steam for the pump. The fireman had a fire that was white hot and that filled the firebox half way up to the flue sheet, but the gage registered only 75 lb. The gage also showed that it was about ready for the scrap heap. The dial glass was gone and also half the pointer. The gage looked as though it had been damaged by fire.

After the fireman hit the gage a couple of cracks with a stick the half pointer jumped up to 105 lb. There was no water glass on this boiler and the try-cocks looked as though they had been but very little used. Trying the lower one and holding a shovel under it, showed no water and as I backed away I asked him where the water was.

"Oh, it's there," said he as he turned on the injector. Water appeared in about three minutes and he considered he had brought the water level up very quickly. The firebox of this boiler was bagged and blistered all around the sides and leaked in two places from what appeared to be cracks in the sheet. Near the door the sheet was red hot on the outside, showing it to be covered with scale up to the door at least.

These boilers were never washed and seldom blown out, it being too much trouble to fill them again, I was informed. After trying the pump once more and reducing the pressure so much that the pump would not run, I went back to the office and reported that the pump was too large for the boilers and started for home, thankful to get away from the place alive and whole.

These boilers are within 100 ft. of possibly twenty-five men, who are working in the quarry, and within a stone's throw of many dwelling houses. Since my visit a boiler maker told me that he had been sent to put a patch on the vertical boiler, but had told the owner that a new firebox was needed as it was impossible to repair the old one. Whether this has been done since I do not know, but these boilers are in operation at this writing and the boiler maker said the pop safety valve on the locomotive-type boiler had become entirely inoperative while he was there, but that they still continued to fire the boiler as usual.

C. L. MALLERY.

Myerstown, Penn.

Phosphorus for Flue Gas Analysis

In a recent issue, L. A. Farrell asks about the use of this substance for the absorption of oxygen. It has the advantage that it will absorb oxygen (theoretically) almost indefinitely and with considerable rapidity. It suffers from the serious disadvantage that there is a small quantity of ozone formed at the same time which oxidizes any carbon monoxide to carbon dioxide, rendering it soluble; also unless kept in the dark it becomes covered with a leathery skin which effectually stops further absorption. Its most serious disadvantage is that it is readily inflammable. If its container be cracked, allowing the water to run out, it will spontaneously take fire, causing the destruction of its container and running down onto the wooden case, setting it on fire. Finally, it is not easily prepared in the small sticks necessary for absorption, and must be handled rapidly and with care to prevent its spontaneous ignition. All these considerations have led me to prefer the slower and more unsatisfactory copper solution.

A. H. GILL.

Boston, Mass.

Regarding the use of phosphorus as a reagent in flue-gas analysis, there is a point that has not been clearly brought out in the discussion. It is that the action of the phosphorus soon becomes slow and then ceases altogether. This characteristic makes it necessary to test the action frequently by introducing a sample of air into the phosphorus pipette when the prompt appearance of the characteristic white fumes shows the material in good condition.

Should the action be unsatisfactory, it is not necessary to throw the remaining phosphorus away or even remove it from the absorption pipette, but only to wash it with water, which can be done by changing the water once or twice.

The solid phosphorus pentoxide P_2O_5 fumes formed in the reaction in the pipette form metaphosphoric acid HPO_3 as they are absorbed by the water, which acid acts to protect the phosphorus from the oxygen.

In handling phosphorus it should always be remembered that it spontaneously ignites in air and that its burns are exceedingly deep and painful. For these reasons it must be stored under water and must never be touched with the fingers in handling.

G. W. MUNRO.

LaFayette, Ind.

Who Is Responsible?

The question in the above heading which appeared on the title page of POWER for Oct. 22 is worthy of considerable thought. In the same issue appear accounts of two boiler-tube accidents in which one man was killed and four others were badly injured. In the previous issue an account also appeared of a bursting boiler-tube accident in which one man was scalded to death and another so badly scalded and burned by flying cinders from the furnace that he was not expected to live, and the engineer died of heart failure due to the same accident.

If Germany or any other country has a law to guard against such injuries and loss of life I say by all means let us enact a similar law. Let us adopt all the essential parts of the German law and add enough to it to meet the conditions under which we are working. I know many readers of POWER are in a position to easily convince their employers of the great protection from injury to have some sort of a locking arrangement to prevent the furnace door from flying open when a tube lets go. Let readers relate their experiences along this line so that we may all work for the same cause and protection. When it has been proved that inward swinging firedoors and other boiler adjuncts are a success, then I think it will be easy to convince the law makers of the good to be derived from the enactment of a law to make their use compulsory.

A. LAMARINE.

New Bedford, Mass.

Air Compressor Efficiencies

The very excellent article on "Air Compressor Efficiencies," by E. M. Ivens, in POWER of Oct. 15, affords an opportunity for discussing the subject and for submitting certain definitions, differing somewhat from those given, as used in the steam and gas engineering department of the University of Wisconsin.

The definition of mechanical efficiency as the ratio of the air horsepower plus the jacket horsepower divided by the indicated horsepower of the steam cylinder cannot be accepted as correct, for this would indicate little advantage in water jacketing other than that of securing lower temperatures, when it is well known that by approaching the isothermal line in compression the actual horsepower required is reduced. The heat given to the jacket represents energy furnished by the moving piston, but this energy is included in the area of the air diagram. In the case of isothermal compression the heat energy given to the jacket is exactly equal to the area of the diagram if clearance is disregarded, while in actual compression the area of the air diagram is equal to the heat given to the jacket plus the additional internal energy given to the air during compression. This point of view is apparent if the fundamental energy laws dealing with compressed air are considered. The energy stored up in compressed air is a direct function of the temperature, and with isothermal compression there is no more energy in the compressed air than in the free air, both being of the same temperature. The only difference is that in the case of the compressed air the energy is available because a drop of pressure—and, therefore, of temperature is possible, while with free air this is not true.

In compressing air isothermally energy is expended in merely changing the energy in free air from an unavailable to an available form, and the work of the air-compressor card shows the energy that is expended to make the energy in air available. It has no reference whatever to the energy in the air.

The definitions given by Mr. Ivens of volumetric efficiencies both observed or apparent and real or true are excellent, but the definition of compression efficiency as illustrated in Fig. 1 is open to criticism in that *df* does not represent the amount of air compressed.

We have used two separate efficiencies in considering the matter of compression, viz., cylinder efficiency and efficiency of compression. Cylinder efficiency is defined as the ratio of the work done in a complete cycle to compress isothermally a volume of air at atmospheric pressure equal to the intake piston displacement, divided by the actual work done in the air cylinder. This is the same as Mr. Ivens' definition of compression efficiency.

Efficiency of compression is defined as the product of the cylinder efficiency and the true volumetric efficiency, or it is the work done in a complete cycle in compressing isothermally without clearance a given volume of free air, divided by the work actually expended in compressing the same volume of free air.

The definition of overall efficiency given by Mr. Ivens is probably not stated as intended by the author for the use of "boiler horsepower" is clearly not justifiable in this ratio. The term boiler horsepower means the evaporation of 34.5 lb. of water from and at 212 deg. F. per hr. and cannot be used in such an efficiency expression.

We use the term "net efficiency" to include all losses of air compression and define it for a steam-driven air compressor, as the ratio of the available energy in the compressed air to the available energy in the steam used. This means the internal energy available in the compressed air at room temperature or the energy available by its adiabatic expansion to atmospheric pressure divided by the energy available in the steam supplied if expanded adiabatically in a Rankine cycle from the inlet to exhaust pressure.

The reason for this term may be clearer from a statement of the changes of available energy from steam to compressed air. The thermal efficiency of a steam cylinder represents the ratio of the heat energy turned to work to the heat energy supplied in the steam. The standard steam-engine cycle used for comparison is the Rankine cycle, in which adiabatic expansion is assumed from inlet to exhaust pressures. The ratio of the actual thermal efficiency of a steam engine to the efficiency of a Rankine cycle between the same limits gives the so called efficiency ratio of the steam end.

If the heat energy available in the steam by adiabatic expansion from inlet to exhaust pressure be multiplied by the efficiency ratio the product will represent the energy of the moving steam piston.

If the energy of the moving steam piston be multiplied by the mechanical efficiency the product will represent the energy of the moving air piston, and if this energy be multiplied by the efficiency of compression the product will represent the energy required to compress isothermally the air actually compressed.

If the compressed air could be expanded isothermally without further addition of energy, the items mentioned would include all the losses of energy. As isothermal expansion without addition of heat is impossible there is a further loss to be considered due to the fact that the energy stored up in the compressed air is measured by the work done by adiabatic expansion to atmospheric pressure.

It will be seen from this that the term "net efficiency" includes losses in the steam cylinder due to failure to realize maximum possible efficiency in utilizing the steam, losses due to friction in the compressor, losses due to faulty valve action, poor design of ports, inefficient cooling, and the inevitable loss of energy due to the fact that the expansion of compressed air follows a different path from the ideal compression line. These losses are all summed up in the term "net efficiency" or the ratio of the available energy in the compressed air to the available energy in the steam used.

H. J. THORKELSON.

Madison, Wis.

The Society for Electrical Development has been incorporated to establish cooperative relations among the different electrical interests in the United States, Canada and Mexico with a view of increasing the use by the public of electrical current and to promote the welfare of individuals identified with all branches of the industry. The principal office will be in New York City.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Relative Resistances of Wires

If the resistance of a piece of round copper wire 0.001 in. in diameter and 1 ft. long is 10.8 ohms, what would be the resistance of 1500 ft. of 1-in. square copper wire of the same kind of copper and at the same temperature?

H. M. H.

The cross-sectional area of 0.001 in. diameter wire is

$$0.001 \times 0.001 \times 0.7854 = 0.0000007854 \text{ } sq.in.$$

and the cross-sectional area of 1 in. square wire would be 1 sq.in., and as the resistances of the wires would be inversely as their cross-sectional areas and directly as their lengths, the resistance of the 1-in. square wire 1500 ft. long would be

$$\frac{0.0000007854}{1} \times 10.8 \times 1500 = 0.0127 \text{ } ohm.$$

Diameter of Steam Pipe

What should be the diameter of a steam pipe for furnishing 200 lb. of steam per min. at a pressure of 105 lb. abs., allowing a pipe velocity of 5500 ft. per min.?

E. R. R.

The specific volume, i.e., the number of cubic feet per pound, of dry saturated steam at the pressure of 105 lb. abs. is 4.230 cu.ft. and the volume of 200 lb. would be

$$4.230 \times 200 = 846 \text{ } cu.ft.$$

To convey this quantity per minute would therefore require the steam pipe to have a cross-sectional area of $846 \div 5500 = 0.1538$ sq.ft. or $0.1538 \times 144 = 22.1472$ sq.in., and the diameter required for the steam pipe would be

$$\sqrt{\frac{22.1472}{0.7854}} = 5.3 \text{ } in. \text{ } diameter.$$

Equivalent Evaporation

A boiler supplied with feed water at 80 deg. F. evaporated 1900 lb. of water per hour into dry saturated steam at 130 lb. per sq.in. abs. pressure; what is the equivalent evaporation from and at 212 deg. F.?

R. E.

Each pound of water fed at 80 deg. F. contains nominally $80 - 32 = 48$ heat units above 32 deg. F., and according to Marks & Davis' steam tables, a pound of water raised from 32 deg. F. to dry saturated steam at 130 lb. absolute pressure would require 1191 heat units. Each pound of water raised from feed water at 80 deg. F. and evaporated under the conditions stated therefore received

$$1191 - 48 = 1143 \text{ } B.t.u.$$

The same steam tables give the latent heat of evaporation of water at 212 deg F. and atmospheric pressure as 970.4 B.t.u. Hence for the conditions stated the factor of evaporation would be

$$\frac{1143}{970.4} = 1.1778$$

and the equivalent evaporation is

$$1900 \times 1.1778 = 2237.82 \text{ } lb.$$

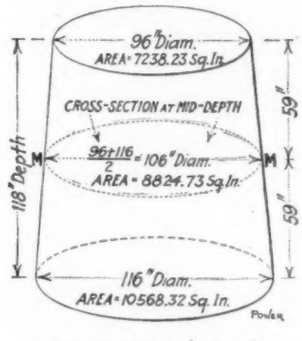
of water evaporated from and at 212 deg. F.

Computing Capacity of Tank

What is the method of computing the capacity, in gallons, of a round wooden tank having inside dimensions of 1196 in. diameter at the top, 116 in. diameter at the bottom, and depth of 118 in.?

W. B.

Referring to the figure the content in cubic inches is found by multiplying by



DIMENSIONS OF TANK

the mean area of cross-section in square inches by the height in inches. The form of the tank being a frustrum of a cone, the mean cross-sectional area is found by adding together the area at the top, the area of the bottom and four times the area of the cross-section at mid depth *MM*, and dividing their sum by six. Employing the values shown in the figure, the mean cross-sectional area would be

$$\frac{7238.23 + 10{,}568.32 + (4 \times 8824.73)}{6} = 8850.91$$

and the volume would be

$$8850.91 \times 118 = 1{,}044{,}407.38 \text{ } cu.in.$$

One gallon being 231 cu.in., the capacity in gallons would be

$$1{,}044{,}407.38 \div 231 = 4521.24 \text{ } gal.$$

Stop Valve for Boiler Inspection

What is the purpose of an inspection stop valve and bleeder on a boiler and how are they placed and used?

A. B. S.

When two or more boilers are connected into the same header, to guard against leakage of steam into a boiler through a single main stop valve during internal examination, the boiler connection to the header is provided with an extra stop valve, and a good-sized bleeder and stop valve are placed between the two main stop valves. For purposes of inspection both of the main stop valves are closed and the bleeder valve is left wide open so as to discharge any steam that may leak through the main stop valve which is next to the header.

Thickness of Boiler Shell

What should be the thickness of the shell of a boiler 60 in. in diameter to carry 70 lb. pressure, the efficiency of the longitudinal seams being 68 per cent. and working strength of the shell plates 9000 lb. per sq.in. of section?

E. R. R.

The shell of a boiler 60 in. in diameter carrying 70 lb. pressure per sq.in. would have to resist a strain of

$$\frac{60 \times 70}{2} = 2100 \text{ } lb.$$

on each inch of length of the shell. The working strength of the solid plate being 9000 lb. per sq.in., the thickness of solid plate required to resist 2100 lb. per in. of length would be

$$\frac{2100}{9000} = 0.2333 \text{ } in.$$

But as the efficiency of the joint is to be 68 per cent., the actual thickness of plate for sufficient strength at the joint would have to be

$$0.2333 \div 0.68 = 0.343 \text{ } in.$$

or

$$0.343 \times 32 = \frac{10.976}{32} \text{ } in.$$

i.e., practically $\frac{11}{32}$ in. thick.

Engineers' Study Course—V

Denominate Numbers

In this lesson we deal with numbers that denominate particular quantities. Thus 6 *feet* is a denominate number because it names, designates or denominates feet. But 7 standing alone might mean seven of anything, as bolts, cylinders, inches, feet, tons, yards, pounds, etc. If standing alone, the number is an *abstract number* because it does not designate any unit or denomination.

Denominate numbers as given in books on arithmetic deal with units of measure, which are quantities established by law as standards to follow in buying, selling and computing quantities of things.

A simple denominate number designates units of only one denomination, as 2 ft.; 6 lb.; 4 tons, etc. A compound denominate number designates units of two or more denominations, as 8 tons, 20 lb., 4 oz., or 2 weeks, 4 days, 3 hours, 4 min. In working examples in denominate numbers all we wish to do is to reduce all the different quantities, as the 8 tons, 20 lb., 4 oz. to a common denomination of tons, pounds or ounces.

There are six kinds of measures:

Weight; Extension; Capacity; Time; Angles; Money.

Money will not be considered as every reader is familiar with American money values. The chief thing to observe in the reduction of denominate numbers is this:

Multiply to reduce to lower denominations and divide to reduce to higher denominations.

Example—Reduce 8 tons, 20 lb., 4 oz. to ounces. One ton = 2000 lb. One pound = 16 oz.

2000 lb.	16020 lb.	256320
8	16 oz.	4
16000 lb.	96120	256324 oz. ans.
20	16020	
16020 lb.	256320 oz.	

Example—Reduce 284 in. to higher denominations: 12 in. = 1 ft.; 3 ft. = 1 yd.

12 in.) 284 in.
3 ft.) 23 ft. + 8 in.
7 yd. + 2 ft. + 8 in. ans.

In the last example 12 in. went into 284 in. 23 times and left a remainder of 8; the divisor 12 was inches and so the remainder must be inches. Eight inches do not equal 1 ft., so it must be added as inches. The 3 ft., or 1 yd., went into 23 ft. 7 times and left a remainder of 2 ft., which is not a whole yard, so the final answer must be 7 yd., 2 ft., 8 in.

To reduce denominate numbers to higher or lower terms we must know the relative values of all the different units; that is, how many ounces there are in a pound, how many pounds in a ton, the number of inches in a foot, how many feet there are in a yard, and also the number of square inches in a square foot or square yard and how many gills in a pint, pints in quarts, quarts in gallons, gallons in a barrel, etc.

We will not go into the addition, subtraction, multiplication and division of compound denominate numbers directly as such, for the average man, will invariably reduce the different denominations to a simple denominate quantity before performing such examples, even though he knows how to do it the other way.

For instance, instead of adding direct 2 cwt. + 150 lb. + 8 oz., most men will say, "2 cwt. = 200; 200 + 150 = 350 lb.; 8 oz. = ½ lb. So the answer is 350½ lb."

The accompanying tables have been compiled chiefly from Hering's book of "Conversion Tables," much of which has been accepted by the National Bureau of Standards and checked by L. A. Fischer, Asst. Phys., National Bureau of Standards. Only those units of measures most used by engineers are given. Their equivalents in units of the metric system are given to further enable the student to convert units of the English system into their equivalents of the metric system. Should the student care to go further into the study of the metric sys-

LENGTH OR EXTENSION

1 mil = 0.001 in.
1 millimeter = 39.370 mils
1 millimeter = 0.039370 in.
1 millimeter = 0.001 in.
1 centimeter [cm.] = 0.3937 in.
1 centimeter = 0.0328 ft.
1 centimeter = 0.01 m.
1 inch [in.] = 1000 mils
1 inch = 25.400 mm.
1 inch = 2.540 cm.
1 inch = 0.0833 ft. or $\frac{1}{12}$
1 inch = 0.2777 yd. or $\frac{1}{36}$
1 inch = 0.0254 m. aprx. $\frac{1}{40}$
1 foot [ft.] (U.S.) = 304.801 mm.
1 foot = 30.480 cm.
1 foot = 12 in.
1 foot = 0.333 yd. or $\frac{1}{3}$
1 foot = 0.3048 m. aprx. $\frac{3}{10}$
1 foot = 0.000304 km.
1 foot = 0.000189 mile
1 yard [yd.](U.S.) = 91.440 cm.
1 yard = 36 in.
1 yard = 3 ft.
1 yard = 0.914 m.
1 yard = 0.000914 km.
1 yard = 0.000568 mile
5.5 yd. = 1 rod.
40 rods [rd.] = 1 furlong [fur.]
8 furlongs = 1 mile
1 mile [ml.] = 5280 ft.
1 mile = 1760 yd.
1 mile = 1609.35 m.
1 mile = 1.609 km.
1 mile = 0.868 nautical mile.
1 knot (U.S.) = 6080.20 ft.
1 knot = 1853.25 m.
1 knot = 1.853 km.
1 knot = 1.151 m.

SURFACES

1 circular mil. [cm.] = 0.785 sq.mil.
1 circular mil. = 0.000001 circ. in.
1 square mil. [M²] = 1.273 circ. mils.
1 square mil. = 0.000001 sq.in.
1 circular inch = 1,000,000 circ. mils.
1 circular inch = 785,398 sq.mils.
1 circular inch = 0.785 sq.in.
1 circular inch = 0.00694 circ.ft.
1 circular inch = 0.00545 sq.ft.
1 sq.inch = 1,273,240 circ. mils.
1 sq.inch = 1,000,000 sq.mils.
1 sq.inch = 1.273 circ. in.
1 sq.inch = 0.008 circ.ft.
1 sq.inch = 0.0069 sq.ft.
1 sq.foot = 183.346 circ. in.
1 sq.foot = 144 in.
1 sq.foot = 1.273 circ.ft.
1 sq.foot = 0.111 sq.yd.
1 sq.yd. = 1,296 sq.in.
1 sq.yd. = 9 ft.
1 sq.yd. = 0.836 sq.m.
1 sq.yd. = 0.000206 acre.
1 sq. meter = 10.763 sq.ft.
1 sq. kilometer [km.²] = 10,763,867 sq.ft.
1 sq.mile = 27,878,400 sq.ft.
1 sq. mile = 640 acres

VOLUME OR CAPACITY

1 cu. centimeter = 0.061 cu.in.
1 cu.centimeter = 0.001 liter.
1 cu.inch = 16.387 cu.cm.
1 cu.inch = 0.034 pt. (U.S.) liquid.
1 cu.inch = 0.017 qt. (U.S.) liquid.
1 cu.inch = 0.004 gal. (U.S.) liquid.
1 cu.inch = 0.000578 cu.ft.
1 pint = 473.179 cu.cm.
1 pint = 28.875 cu.in.
1 pint = 16 fluid ounces.
1 pint = 4 gills (U.S.)
1 pint = 0.5 qt. (U.S.) liquid.
1 pint = 0.125 gal. (U.S.) liquid.
1 pint = 0.016 cu.ft.
1 quart [qt.] (liquid; U.S.)
1 quart = 946.35 cu.cm.
1 quart = 57.75 cu.in.
1 quart = 8. gills
1 quart = 0.25 gal.
1 quart = 0.033 cu.ft.
1 quart = 0.946 liters.
1 gallon = 3785.43 cu.cm.
1 gallon = 231 cu.in.
1 gallon = 32 gills.
1 gallon = 4 qt.
1 gallon = 3.785 liters
1 gallon = 0.133 cu.ft.
1 cu.foot = 28,317 cu.cm.
1 cu.foot = 1728 cu.in.
1 cu.foot = 59.844 pt.
1 cu.foot = 29.922 qt.
1 cu.foot = 28.317 liters.
1 cu.foot = 7.480 gal.
1 cu.meter = 61,023.4 cu.in.
1 cu.meter = 1000 liter
1 cu.meter = 35.314 cu.ft.

Note: The volume of a barrel is not given as it varies with different manufacturers marketing products by the barrel. The barrel is not a fixed unit and no value has ever been adopted by Congress.

WEIGHT

1 milligram [mg.] = 0.1 cg.
1 milligram = 0.001 gram
1 centigram [cg.] = 10 mg.
1 centigram = 0.01 gram
1 grain [gr.] = 0.064 gr.
1 grain = 0.002 ounces (oz.)
1 gram [g.] = 15.432 gr.
1 gram = 0.035 oz. (av.)
1 gram = 0.032 oz. (troy)
1 gram = 0.001 kilogram (kg.)
1 ounce [oz.] = 437.5 gr.
1 ounce = 28.349 g.
1 ounce = 16 drams
1 ounce = 0.062 lb. (av.)
1 ounce = 0.028 kg.
1 pound [lb.] = 7000 gr.
1 pound = 453.59 g.
1 pound = 256. drams (av.)
1 pound = 16. oz.
1 pound = 0.453 kg.
100 pounds = 1 hundredweight (cwt.)
1 kilogram or kilo [kg.] = 15,432.356 gr.
1 kilogram or kilo = 1000 g.
1 kilogram or kilo = 35.274 oz. (av.)
1 kilogram or kilo = 2.204 lb.
1 ton [tn.] = 2000 lb. (short ton)
1 ton = 20 cwt.
1 ton = 907.185 kg.
1 ton = 0.907 metric ton.
1 long ton = 2240 lb.
1 long ton = 1016.05 kg.
1 long ton = 1.12 short tons
1 long ton = 1.16 metric tons

tem and the conversion of units he should consult some book on the subject.

These tables are good for reference for ordinary work and we suggest that the student file them for this purpose.

MEASURE OF ANGLES OR ARCS

60 seconds [″] = 1 minute [′]
60 minutes = 1 degree [°]
90 degrees = 1 right angle or quadrant [L]
360 degrees = 1 circle [cir.]
1 circle = 360° = 21,600′ = 1,296,000″.

THERMOMETER SCALES

1 centigrade degree = $\frac{9}{5}$ or 1.8 deg. Fahrenheit
1 centigrade degree = $\frac{4}{5}$ or 0.8 deg. Reaumur
1 Fahrenheit degree = $\frac{5}{9}$ deg. Centigrade
1 Fahrenheit degree = $\frac{4}{9}$ deg. Reaumur
1 Reaumur degree = $\frac{5}{4}$ or 1.25 deg. Centigrade
1 Reaumur degree = $\frac{9}{4}$ or 2.25 deg. Fahrenheit.

Paper Measure

1 quire = 24 or 25 sheets
1 ream = 20 quires = 480 sheets
1 ream generally = 500 sheets

Miscellaneous Measure

1 dozen (doz.) = 12
1 gross = 12 doz. = 144
1 great gross = 12 gross
1 score = 20

POWER

1 horsepower [hp.]	= 33,000 ft.lb. per min.
1 horsepower	= 550 ft.lb. per sec.
1 horsepower	= 746 watts.
1 horsepower	= 0.746 kw.
1 horsepower	= 42.41 B.t.u. per min.
1 horsepower	= 1.014 metric hp.
1 horsepower	= 375 mile-pounds per hr.
1 horsepower	= 10.7 large calories per min.
1 kilowatt [kw.]	= 44,256.7 ft.-lb. per min.
1 kilowatt	= 737.7 ft.-lb. per sec.
1 kilowatt	= 1000 watts
1 kilowatt	= 1.34 hp.
1 kilowatt	= 56.9 B.t.u. per min.
1 kilowatt	= 1.36 metric hp.
1 kilowatt	= 14.34 large calories

PRESSURES

1 foot of water column	= 304.8 kg. per sq.m.
1 foot of water column	= 62.4 lb. per sq.ft.
1 foot of water column	= 0.433 lb. per sq.in.
1 foot of water column	= 0.029 atmosphere [atm.]
1 inch of mercury column [in.hg.]	= 345.4 kg. per sq.m.
1 inch of mercury column	= 70.7 lb. per sq.ft.
1 inch of mercury column	= 0.491 lb. per sq.in.
1 inch of mercury column	= 1.132 ft. of water
1 inch of mercury column	= 0.033 atm.
1 inch of mercury column	= 0.345 meters of water

To convert a reading in *Centigrade Degrees* into corresponding Fahrenheit degrees, multiply by $\frac{9}{5}$ and add 32 (because the zero on the Fahrenheit scale is 32 deg. F. below zero on the Centigrade scale). Multiply Centigrade degrees by $\frac{4}{5}$ to convert the reading into Réaumur degrees. To convert *Fahrenheit Degrees* into Centigrade degrees, subtract 32 and multiply by $\frac{5}{9}$. To convert Fahrenheit into Réaumur degrees, subtract 32 and multiply by $\frac{4}{9}$. To convert *Réaumur Degrees* into Fahrenheit degrees, multiply by $\frac{9}{4}$ and add 32.

EXAMPLES FOR PRACTICE

(1) Reduce 20 tons, 105 lb., 6 oz. to oz.

(2) Reduce 1 mile, 227 ft., 10 in. to inches.

(3) How many inches in 20,000 mils?

(4) How many centimeters in $\frac{1}{12}$ ft.?

(5) How many centimeters in 25 ft.?

(6) A cable is 10,560 yd. long. (a) How long is it in miles? (b) How long is it in kilometers?

(7) If a vessel travels 20 knots, how far does it travel in land miles?

(8) A square foot contains 144 sq.in. How many circular inches does it contain?

(9) The floor area of an engine room is 1240 sq.ft. How large is it in square meters?

(10) (a) A tank contains 8000 gal. of water. How many liters does it contain? (b) What is the volume of the tank in cubic inches?

(11) One cubic foot equals how many cubic inches?

(12) 372,155.5 kg. of coal are received. What is the equivalent in short tons?

(13) Neglecting losses, how many British thermal units must be supplied to a 500-hp. engine to run it one hour?

(14) The water pressure due to the height of a factory tank is 80 lb. (a) How high is the tank? (b) How many feet high would a mercury column need to be to balance this pressure?

ANSWERS TO LAST WEEK'S QUESTIONS

(1) 0.1; 0.09; 0.095; 3.1915; 123.09

(2) 1010.24 + 2.222 + 19.005 + 0.0026 + 51.2 + 3.1416 = 1085.8112

(3) 1029.56 — 350.05 lb. = 679.51 lb.

(4) 4.59 × 42 = 192.78 gal. per min. are pumped; 192.78 gal. × 219.5 min. = 42,315.21 gal. total gallons pumped.

(5) 15,125 lb. ÷ 27.5 lb. = 550 = horsepower of engine; 15,125 lb. ÷ 9.5 lb. = 1592.3 lb. of coal used; 1592.3 ÷ 550 = 2.89 + lb. of coal per hp. per hr.

Economy in a Small Plant*

At the plant of the Buffalo Coated Paper Co. some interesting data were obtained showing what can be accomplished in a small plant by a good engineer employing modern methods. The plant has two 125-hp. return-tubular boilers which have seen over ten years of service. Less than a year ago a new 250-hp. engine was installed to replace an engine which the load had outgrown.

For several years the average daily fuel consumption for the boilers was from 6½ to 7 tons of coal, the yearly contract specifying the requirements at about 2300 tons. The plant was operated 60 hr. per week, 11 hr. daily through the week and 5 hr. on Saturday. A day and night fireman were employed, and the former, with the chief engineer, were on duty 11 hr., namely, from 7 a.m. to 6 p.m., the night fireman serving 13 hr. Besides furnishing steam for power, it was necessary to maintain a constant temperature throughout the night in the drying room where the paper was coated, and besides steam was employed to heat the air passing through the blowers to the drying room during the day. The engineer's report stated, however, that the plant was in actual operation 78 hr. each week. This, of course, included the time of getting up steam pressure in the morning and very often operating the main engine to run certain parts of the machinery before 7 a.m. or after 6 p.m.

About the first of January last the engineer started the new year by removing 1000 lb. of scale from the two boilers. This in itself showed a marked reduction in fuel consumption, but with this the engineer was not satisfied, and in April began to analyze the gas. From this time on a daily log was kept, giving the quantity of water metered, the daily average CO_2 for each boiler, etc.

From Sept. 3 to 18 inclusive the plant was in operation 142 hr. The coal consumed during that time was 36¾ tons. During the same period the night fireman was on duty 194 hr. and consumed 50 lb. less than 9 tons of coal. The average hourly evaporation for each day was 3326 to 4278 lb., the daily feed-water temperature varying from 179 to 200 deg. F. and the average daily steam pressure from 76 to 82 lb. gage. The average evaporation from and at 212 deg. was 10.36 lb. per lb. of coal burned, and the average coal consumption per horsepower-hour was 3.34 lb. The lowest average daily CO_2 reading in either boiler was 10 per cent., and the highest 12.4 per cent.

The first daily average of CO_2 readings which were taken some two weeks after the instruments were installed showed about 6½ per cent. The readings steadily improved, however, and on July 15 a daily average of 10 per cent. was obtained, and at the present writing this figure is considered a poor showing.

Scale has been removed from the tubes of No. 1 boiler twice and from No. 2 boiler once since January, and the engineer is positive that the plant can be operated with a daily coal consumption of not much in excess of 2½ tons, if the steam requirements are not increased. The concrete results of this work were shown when the coal salesman recently came to obtain the contract for next year's supply for the requirements were reduced to 1000 tons per annum. During the year, numerous trials were made with different grades of coal, on the thickness of the fuel bed, the draft and other data tending to produce the best results.

From this work it is very evident that the installation of CO_2 recorders and other accessories are of no particular value in themselves without the coöperation of an intelligent and progressive engineer and fireman. With men capable of this coöperation the results show what can be accomplished even in an ordinary plant if uptodate methods are followed. The annual saving of this company in power-plant operation is now nearly $3000, which is equal to the wages paid to the engineer and the two firemen.

*From data supplied by the William B. Pierce Co., of Buffalo, N. Y.

Over the Spillway

Just Jests, Jabs, Joshes and Jumbles

An anonymous well wisher sends us a three-page pome for this column and ventures to hope that we may be able to publish it "By arangeing the Punctiation Capitals etc." Our literary repair shop is already crowded, and, anyway, we hold fast to our rule never to do a job of any kind for unknowns.

Our valued contributor, W. J. Au, is hereby installed in our hall of fame. There are still several choice niches, with all the modern improvements, unoccupied. Who's next?

A French scientist has discovered that a hypodermic injection of formic acid will cure the most obstinate case of laziness. Don't believe it! Recently, we saw a power-plant employee who couldn't move fast enough to get in a moving picture. He could defy a heavy charge of dynamite and get away with it.

The general manager glanced casually at the graduate. "I have no position to offer you," he said. "You misunderstand," responded the graduate. "What I want is a job." Two minutes later he was at work.

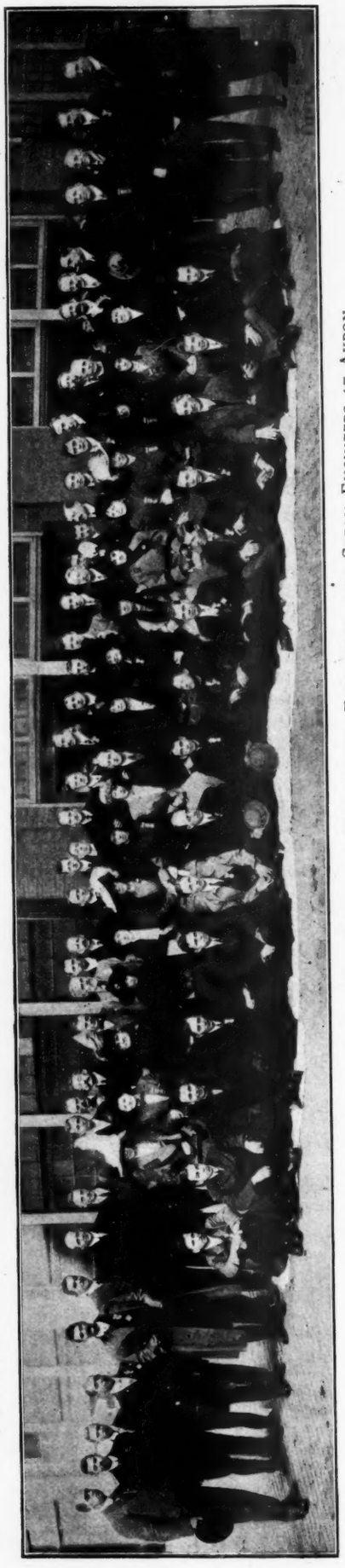
"Illuminating engineers are making a fight against glare." He must be a sassy old thing who would glare at a poor engineer, although we have a couple of strong glares tucked away for the "engineer" who hung, about a mile over our desk, a faint ray which looks like that 16-cp. lamp in the Goddess of Liberty's fist.

"Koo'-chook!" Sounds like a cold in the head or the name of a captured Turkish town. "Caoutchouc," of course, means india rubber; trying to pronounce it without the aid of a diagram means much profanity. We bounce it. "Rubber" suits us.

You can jolly well believe no operating engineer would short-circuit our classic language as did a coal-mine machine runner in the following bulletin:

no. 4 Masheen awl Shot tu hel. Chain brok. fix the dam thing. it brok twict Last nite. amatoor smoks like heltoo. power bad. lots of short circles. this is the masheen with self compeller truck. weer outa oil tu.

One more jest, a jab or josh—
We've *got* to fill this space, b'gosh!
Sometimes, we can write a volyum—
Ha! This last line fills the colyum!



MEMBERS AND GUESTS OF THE OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS AT AKRON

Ohio Society of Mechanical, Electrical and Steam Engineers Meet

The fall meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers was held at Akron, Ohio, on Nov. 21, 22 and 23, with headquarters at the Hotel Portage.

Following an informal reception to the guests and visitors at the Portage on Thursday afternoon the first regular session was held in the evening at the auditorium of the South High School and was opened by an address of welcome by Mayor Rockwell, of Akron; E. M. Adams, president of the society, responded.

The paper of the evening was on "A System of Gas Engine Governing," by George S. Cooper, who discussed in detail the limitations of the hit-and-miss, the throttling, and the variable mixture methods of governing, and pointed out the advantages of combining the two latter methods.

Professor Magruder also made a few remarks in which he pleaded for the establishment of a state engineering-experiment station at the Ohio State University. He pointed out that Illinois, Kansas, Missouri and Iowa now have such experimental stations and Ohio frequently is compelled to submit engineering problems to the University of Illinois. He further emphasized the importance of such a station from an economic point of view.

On Friday evening two very interesting papers were read: "The Lentz System Applied to Steam Engines," by Siegfried Rosenzweig and "The Manufacture of Tin Plates," by E. W. Patten. The former referred to the great steam economies being attained in Germany by the application of poppet valves and high superheat to steam engines. (An abstract of this paper will appear in a later issue.)

Akron, because of its growing importance as a manufacturing center proved an admirable convention city, affording opportunities for many interesting inspection trips. These included visits to the plants of the B. F. Goodrich Rubber Co., the largest of its kind in the world, the Babcock & Wilcox Co., at Barberton, Ohio, makers of the Stirling boiler, the Quaker Oats Co. and a trip through the new power house of the Northern Ohio Traction Co.

The social program for the ladies included a theater party and automobile trips to several points of interest, including a trip to O. C. Barber's farm at Barberton.

The members and guests were tendered a complimentary dinner at the Hotel Portage on Friday evening.

Springfield, Ohio, was selected as the place for the next meeting.

The supply men were well represented

and a number of interesting exhibits were displayed. Among the exhibitors were V. D. Anderson Co., of Cleveland, Bird-Archer Co., of Pittsburgh, the Carey Co., of Akron, C. E. Squires Co., the Crane Co., of Chicago, the Crown Manufacturing Co., of Cleveland, Clement Restein Co., of Philadelphia, the Dearborn Drug & Chemical Works, the Dodge Manufacturing Co., the Flanner Boiler Co., of Toledo, Hoovens, Owens, Rentschler Co., the Homestead Valve Co., Jenkins Bros., the Lagonda Manufacturing Co., the Lunkenheimer Co., W. M. Pattison Supply Co., the William Powell Co. the Schaeffer & Budenberg Manufacturing Co., Tomlinson Steam Specialty Co. and the Union Rubber Co.

NEW PUBLICATION

HOW TO READ A DRAWING. By Vincent C. Getty. J. B. Lippincott Co., Philadelphia. Cloth; 63 pages, 6x9 in.; 61 illustrations; 10 chapters. Price, $1.

Both the drawings and text of this book bear the marks of fearless, wholesome and practical treatment of the subject of mechanical drawing without introducing any unnecessary technicalities or burdening the reader with any fads or fancies of the subject that are of no moment to the practical engineer or mechanic.

Drawing is a language by which we are frequently enabled to convey thoughts and ideas that would be impossible for us to express in words and such wonderful progress has been made in the art and science of representation that many savants who are posted in the world's work of today are inclined to predict that we are rapidly returning to a language of signs which, while more elaborate, is to be a repetition of the hieroglyphics of the ancients. The author may have had this idea before him in selecting the title "How to Read a Drawing," for he not only teaches the reader by easy stages how to read a drawing, but also makes it evident how to make a good mechanical drawing.

Good practical examples of different kinds of drawings are given which are both interesting and instructive, and by perusing the pages of this work any operating engineer should become enabled not only to read drawings but to well represent his own ideas in mechanical drawings, albeit they may lack in the technique of the finished draftsman.

N. A. S. E. Lecture on Safety Devices

Talking before Newark (N. J.) No. 3 Association, N. A. S. E., on safety devices in factories, Monday evening, Nov. 25, Col. Lewis Bryant, commissioner of labor for New Jersey, thanked the engineers for the assistance they have given his department. The engineer, the commissioner said, was the connecting link between the department of labor and the factory owner and manager.

Col. Bryant was pleased when the management of a factory selected its engineer as factory fire chief as the engineer was usually a good adviser to a management reluctant to install the protective apparatus recommended by the department.

A national museum at Washington was much needed for the purpose of exhibiting and testing safety devices and collecting more detailed statistics relative to the number and kind of accidents of which workers are the victims. The commissioner also pointed out how valuable were the recommendations of the National Board of Fire Underwriters. If he wished to know how good a certain apparatus was for fire prevention or protection he could quickly obtain full particulars from the Underwriters. On the other hand, if information was needed on the value of a safety device for a machine, he had to "dig up the information for himself" and then was not sure he had the best device.

In the discussion on the use of the nonreturn stop valve on boilers, the commissioner said his department had not recommended their use. The valve was then described and he promised to investigate its merits.

SOCIETY NOTES

The *Quarterly* of the American Institute of Architects will shortly be changed to a monthly, to be known as the *Journal of the American Institute of Architects*. J. Horace McFarland, Harrisburg, Penn., will be its publisher, D. Knickerbacker Boyd its editor and R. M. Hooker, New York City, its business manager.

The nominating committee of the American Society of Heating and Ventilating Engineers has selected the following names for officers for the next year. They will be elected by a mail ballot, the result to be announced at the annual meeting, which will probably take place Jan. 21, 22 and 23, 1913: President, John F. Hale, Camden, N. J.; vice-presidents, Edmund F. Capron, Chicago; Albert B. Franklin, Boston; treasurer, James A. Donnelly, New York; managers, Frank T. Chapman, New York; Ralph Collamore, Detroit; D. D. Kimball, New York; W. W. Macon, New York; J. M. Stannard, Chicago; Theodore Weinshank, Indianapolis.

A number of Chicago members of the American Society of Mechanical Engineers held a meeting at the Engineers' Club in that city on Nov. 21 to discuss the formation of a local section. P. M. Chamberlain acted as chairman. Representatives of the Western Society of Engineers, the American Institute of Electrical Engineers and the American Institute of Mining Engineers were present, and told of the benefits derived from local sections in other cities.

Dean Goss, of the University of Illinois, made an address on the benefits to be derived from a local section. The sentiment of the meeting was unanimous in favor of the formation of a local section and the holding of regular meetings, and the matter of arranging the details was left to a committee which will draw up a tentative plan to be submitted at a later meeting.

PERSONAL

Thomas A. Edison has been elected president of the Edison Manufacturing companies, succeeding Frank L. Dyer, resigned.

William B. Dickson, first vice-president of the United States Steel Corporation, has been elected president of the International Steam Pump Co. The presidency has been vacant since the death of Benjamin Guggenheim.

Harry Dix, for two years in charge of the heating and ventilating department of the Douglas Milligan Co., Ltd., has joined the engineering staff of the Canadian Domestic Engineering Co., Ltd. Mr. Dix is a Boston man who settled permanently in Canada several years ago.

Harry W. Jarrow has accepted the position of general sales manager for the Diamond Power Specialty Co., Detroit, Mich. Besides a broad selling experience, Mr. Jarrow brings to the technical side of his new work a mechanical engineer training gained both at the University of Pennsylvania and at the Armour Institute of Technology, of Chicago.

The following appointments were made recently by the Magnolia Metal Co.: J. W. Wright, formerly sales manager of the Griscom-Spencer Co., is special representative on the Pacific Coast, with headquarters at San Francisco. William H. K. Gamble, formerly Southern representative of Charles A. Schieren & Co., special representative in the Southwestern territory, with headquarters at Dallas, Tex.

Capt. Robert W. Hunt, of Chicago, has been awarded the John Fritz medal for this year. Capt. Hunt was one of "John Fritz's boys." When about 20 years old he began work in the iron industry at Pottsville, Penn. Later he studied chemistry and became the chemist of the Cambria Co. He was at various times the superintendent of steel works in Wyandotte, Mich., Johnstown, Penn., and Troy, N. Y. In 1888 he founded the firm of R. W. Hunt & Co., consulting engineers, inspectors, etc. He served in the Civil War from 1861 to 1865, rising from private to captain.

Moments with the Ad. Editor

In a certain street in Brooklyn lives a man whom the children call "Crazy Jimmie."

He is a perfectly harmless old fellow, always good natured, always ready to stop and chat with man or woman and to play with a child or pet a dog.

He earns his living by gathering stray dimes, quarters and half-dollars from housewives by doing odd jobs for them, washing down stoop fronts, carrying up coal, splitting wood, washing windows and similar tasks.

Nothing crazy about that, you see. What has gained him the name, however, is the way he goes around the street singing and laughing so that people sitting in their easy chairs smile at each other and say, "There goes poor Crazy Jimmy."

The other day several of us stopped him in the street and talked for a few minutes. He spoke very intelligently in a simple, everyday sort of way.

"Well, Jimmie," said one of the party, "You're all right except for one thing. Why do you shout and sing in the streets so?"

"That's how I get my living," answered Jimmy.

"But I thought you did odd jobs around houses and work like that."

"I do. But if I didn't sing and shout in the street the ladies would forget all about me. Now when they hear me they come out and say, 'Hey, Jimmie, I've got a job for you.'"

So after all poor Jimmie's craziness is nothing more than knowing enough to advertise his services.

* * * * * *

The great force and power that is modern advertising must have originally started in some humble and obscure way similar to that in which Jimmie offers his services.

Perhaps the oldest form of advertising of which we know is the town-crier who, very like Jimmie, used to wander through the streets and lanes of old-time towns crying out the great happenings of the day and also of the wares and goods of enterprising local merchants.

In fact, there is one town-crier still plying his quaint trade in the ancient village of Provincetown, up on the end of Cape Cod, in Massachusetts.

How inadequate that method seems in these days of wide reading, in universal interest in advertised goods—

When one popular weekly carries its message of reliable clothes, household utensils, food and other things to more than two million people—

When "Power," this paper of yours, every week gives over 30,000 of you the opportunity of reading about reliable machines and devices that will help you in your work, help to make your plant more efficient, help you in many cases to benefit yourself financially and in your surroundings.

In the old days of the town-crier there would have been a very limited chance for you to hear of and examine and, in time, use these products.

In these latter days of the printing press you should certainly be glad of and use the opportunity—*continuously*. Get the habit of reading the advertising pages of "Power."